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ERTAIN GENETIC CHARACTERISTICS OF DARK SOILS F LARGE DEPRESSIONS

.A. RODE, YE. A. YARILOVA, and I. M. RASHEVSKAYA,[1] V. V. Dokuchayev Soil Institute,
ademy of Sciences, USSR

The soils of large depressions which we are
ing to describe here, are found in the north-
estern part of the Caspian lowland. They are
nall (relative depth, 1-1.5 m), flat-bottomed
pressions, usually more or less circular or,
ore rarely, elongated in shape, covering
eas from 1-2 to 100 ha, and scattered over
e surface of the ideal plain of the Caspian
wland. The total area covered by such de-
essions does not exceed 10% of the entire
rritory. The remaining, predominant part
the plain has complex soil in which solonchak
lonetzes predominate. In certain years the
rge depressions fill with meltwater in spring,
ich penetrates through the soil and causes the
ound water to rise and sometimes come close
the surface. The rest of the time the ground
ter is found at a depth of 6-7 m as in the rest
the plain.

This periodic leaching of the soil in spring
d its filling with water causes the removal of
lts from the soil, except for calcium carbon-
, and the development of abundant grass
xed-herb vegetation, under which a soil
ms that resembles leached chernozem in
er appearance. The parent material con-
ts of carbonate fine clay loam, very uniform
texture both with depth and extent (Table 1).
e thickness of the soil profile, as determined
the thickness of the root zone under natural
getation, is 300-320 cm. At the present time,
majority of the depressions is under plowland,
in the form of abandoned land of various ages.
til recently they were the only reserves of
ble land and were the backbone of "depres-
n agriculture."

The study of profile 19-a, under wheatgrass,
ves as the basis of this article. The study
made in the southwestern part of depres-
n No. 1, in the area of the Dzhanybek station
he Academy of Sciences, USSR.

The soil profile at the place where it was dug had the following structure.

A humus horizon at a depth of 0-30 cm. Dry, dark-gray, of a rather uniform color throughout its thickness. Medium clay loam. To a depth of 22 cm, plowed, loose and of a powdery-blocky structure. Deeper it is more compact and of a lumpy-prismatic structure. The prisms are 8-10 cm wide and separated one from the other by clearly expressed cracks and crumble into angular fragments.

Micromorphological investigation showed that the soil mass consists of angular and rounded, not very compact microaggregates, 0.08-1.5 mm in diameter, separated from each other by a system of microfissures and pores of various sizes and shapes (Fig. 1a). There are very few plant remains and these are small and greatly modified. The humus is diffuse and impregnates the clay soil mass and also occurs in the form of small dark particles, often forming accumulations (up to 0.1 mm in diameter). Its amount decreases with depth. It is distributed unevenly; there are areas (up to 0.5 mm in diameter) lacking it almost completely and consisting of ferruginized clay, including, as the rest of the mass, mineral fragments of various sizes, and in individual cases only clay particles. Under crossed nicols the clay substance appears oriented in the form of small shells, often forming thin stria. These areas are sometimes rounded in outline and their peripheral portion separated into a number of layers by concentric cracks, exhibits wavy extinction; this clay substance is enriched in many cases with iron hydroxide and humus and forms microconcretions (up to 0.4 mm in diameter). Some of these reach a diameter of 1 mm at a depth of 20-30 cm and consist mostly of two or three concentric layers, in which sometimes the clay substance, sometimes iron hydroxide, and sometimes humus predominate (Fig. 1b). It is sharply distinguished from the underlying horizon by its color and structure.

At a depth of 30-68 cm the soil is clay, leached from carbonates. It is dark cinnamon-brown, becoming somewhat lighter in its lower third. It is fine clay loam, dry, compact, with a clearly defined prismatic structure. The prisms, which are 4-5 cm across, crumble in

---

The work was divided as follows: A. A. Rode
lected the material and described the profile. All
lytical work was done by I. M. Rashevskaya. Ye.
Yarilova performed the micromorphological and
eralogical investigations. The text was written
A. A. Rode and supplemented by Ye. A. Yarilova.
conclusions were made collectively.

Table 1

Particle size analysis of dark soil in a large depression, %

Depth, cm	Losses on washing with hydrochloric acid	Diameter of particles, mm								
		in % of the dry weight of soil washed with hydrochloric acid								
	in % of soil weight	1—0,25	0,25— —0,05	0,05— —0,01	0,01— —0,005	0,005— —0,001	0,001— —0,0002	<0,0002	<0,01	<0,001
0—10	1,1	0,8	7,2	41,1	11,1	13,9	10,8	15,1	50,9	25,9
10—20	1,0	0,6	11,4	37,8	10,8	14,2	9,6	15,6	50,2	25,2
20—30	1,0	1,0	9,2	39,5	10,4	13,5	9,6	16,9	50,4	26,5
30—40	0,8	0,5	8,6	35,7	8,9	10,6	10,7	24,9	55,1	35,7
40—50	1,2	0,1	5,1	31,3	7,5	9,5	10,9	35,6	63,5	46,5
50—60	1,0	0,1	1,3	34,2	7,6	8,9	12,3	35,5	64,3	47,9
60—70	1,1	0,1	5,2	34,2	7,3	8,7	11,5	33,0	60,5	44,6
70—80	10,2	0,0	9,8	38,5	7,1	7,8	9,9	26,8	51,6	36,7
80—90	16,4	0,0	13,1	34,4	8,3	8,6	8,7	26,9	52,5	35,7
90—100	18,2	0,0	9,5	37,4	9,0	7,7	9,2	27,2	53,1	36,5
100—110	18,9	0,0	13,4	36,1	7,9	8,2	8,0	26,4	50,5	34,4
110—120	19,6	0,0	14,2	35,1	8,1	8,7	7,1	26,8	50,7	33,9
120—130	17,4	0,0	15,6	37,1	6,9	8,5	6,7	25,0	47,1	31,2
130—140	18,8	0,0	11,2	42,9	6,3	8,0	6,3	25,3	47,9	31,6
140—150	18,3	0,0	13,1	39,1	7,7	7.7	6,5	25,7	47,6	32,3
150—160	17,9	0,0	12,6	38,7	8,2	7,7	8,1	24,5	48,5	32,7
160—170	17,1	0,0	13,8	37,5	7,2	8,2	7,9	25,4	48,7	33,2
170—180	15,7	0,0	10,9	41,2	7,8	8,0	7,9	24,2	47,9	32,1
180—190	14,5	0,0	19,3	34,6	7,5	7.8	6,7	24,0	46,0	30,8
190—200	14,5	0,0	14,9	38,4	7,2	8,4	7,3	23,7	46,6	31,1

Note: Comma represents decimal point.

a horizontal direction into parallelepipedal fragments. It begins to effervesce from hydrochloric acid at its lower boundary.

Micromorphological investigations showed that the soil in this horizon is dissected by primarily larger pores (up to 1 mm in diameter) and fine vertical and horizontal cracks. The clay portion, which contains almost no organic matter, is of a bright brown color and under crossed nicols exhibits an orientation in the form of fine discontinuous striae along cracks (Fig. 1c). Mineral fragments are surrounded by polarizing clay films (Fig. 1d). There are more areas with the polarizing clay substance such as in the upper layer. There are individual tongues of clay material and of a more homogeneous collomorph clay substance with a clearly defined stratification in small pores. The amount of microconcretions decreases from a depth of about 50 cm and they become smaller. It merges rapidly into the underlying horizon (by color), but there is no sharp boundary.

At a depth from 68-200 cm the soil is calcareous. It is brownish-yellow, rather light in color, medium clay loam, and dry. It contains rare, clearly outlined, vertically elongated krotovinas, 3-4 cm across. It has a pronounced nutty-prismatic structure which becomes less pronounced at a depth of about 200 cm (the prisms fuse). Efflorescence rather violently from hydrochloric acid. At a depth from 85-200 cm it contains white specks in the form of clearly outlined, rather rare white spots about 10 mm in width and 20-50 mm long, elongated in the vertical direction. There are veinlets of carbonates on the surface of individual particles at a depth from 100-180 cm. Live roots penetrate to the bottom of the pit.

Micromorphological investigations showed that at a depth from 70-80 cm small calcite grains of an irregular shape are scattered in the soil mass. There are also larger grains of an elongated shape with transverse, or oblique, filements, which do not show extinction (probably pseudomorphs of calcite along root remains). From a depth of about 90 cm the soil contains a larger amount of microcrystalline calcite forming small, compact accumulations in the pores (Fig. 1e). The amount of microcrystalline calcite increases with depth. At a depth of about 100 cm, poorly defined concretions of a clay substance lacking iron hydroxide appear; they exhibit wavy extinction along the periphery (Fig. 1f). Starting from a depth of 120 cm, the amount of microcrystalline calcite diminishes gradually and it is distributed less evenly. In such areas where it is almost completely absent there are striae of a clay substance; this substance sometimes contains microcrystalline calcite. At a greater depth the soil changes into parent material.

Before examining the analytical data, let us describe some analytical and calculation method.

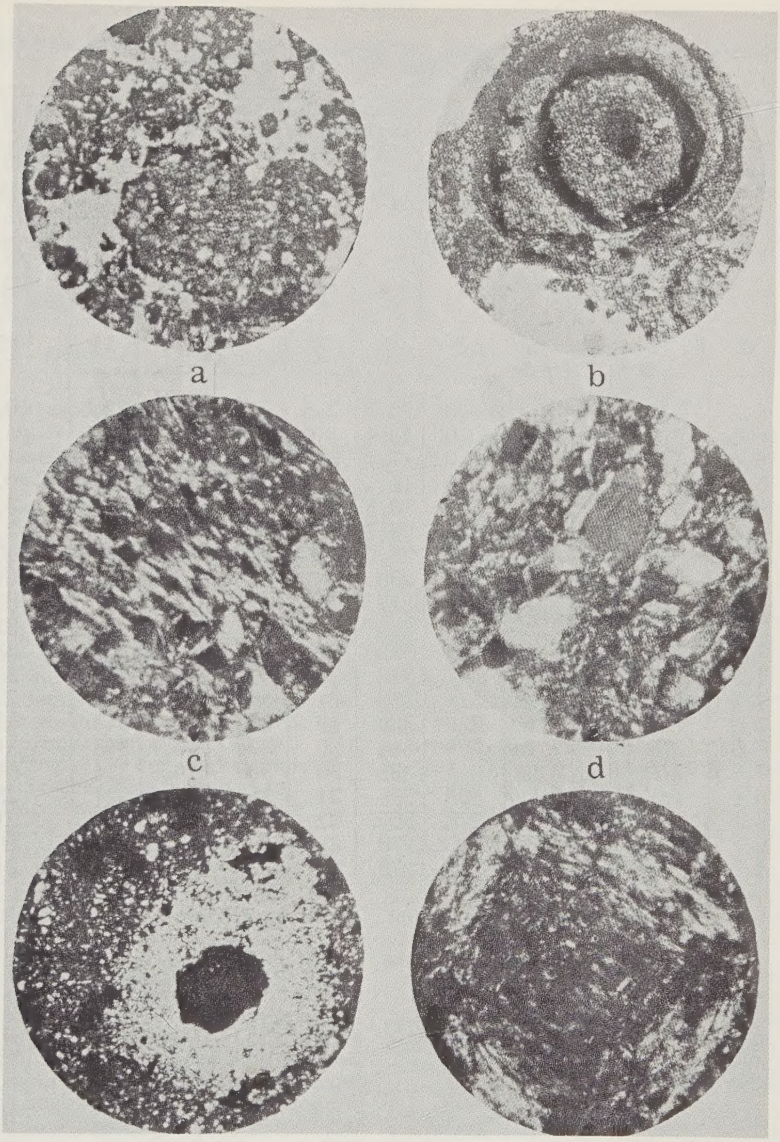

Fig. 1. - Micromorphology of the dark soil in a large depression (Profile 19-a)

a - microstructure of the humus horizon of the soil. Magnified 80 times; b - microconcretions from a depth of 35 cm. Magnified 80 times; c - orientation of the clay portion of the soil at a depth of 45-55 cm in the form of thin striae (they look lighter on the microphotograph). Magnified 300 times, nicols +; d - polarizing films of oriented clay around fragments of primary minerals (they look lighter on the microphotograph). Magnified 80 times, nicols +; e - accumulation of microcrystals of calcite around micropores at a depth of 120 cm. Magnified 80 times, nicols +; f - areas with a clay substance in the carbonate horizon with a concentric orientation of its particles. Magnified 300 times, nicols +.

Table 2, columns 7, 8, and 9 give the total ontent of exchangeable and carbonate Ca and Ig cations and their sum total. These values epresent the total content of Ca and Mg going nto solution during the treatment and washing f the soil sample with an ammonium acetate solution (half normal), until the reaction to the Ca ion completely disappears in the filtrate. Since easily soluble salts (sulfates and chloridea) are practically absent in the soil (column 13), we may rightly consider the amount of Ca and Mg going into solution in the ammonium

Table 2

Content of humus, carbonate carbonic acid, exchange cations, pH, and exchange capacity of dark soil in a large depression for 100 g of dry soil

Depth, cm	pH		Humus %	Carbonate CO_2		Total of exchange and carbonate cations of Ca and Mg, meq			Exchange capacity, in meq	Total carbonate CO_2 and exchange capacity, meq	Excess of total exchange and carb. Ca and Mg over the tot. of carbonate CO_2 and exch. cap., meq	$SO_4^=$ entering the filtrate during washing with 0.05 HCl, meq
	Water	Salt		In%	In meq	Ca	Mg	Total				
1	2	3	4	5	6	7	8	9	10	11	12	13
0—10	6,2	5,5	3,2	0,0	0,0	19,8	3,5	23,3	22,6	22,6	0,7	Not det'd
10—20	6,1	5,3	3,1	0,0	0,0	16,1	3,9	20,0	24,2	24,2	—4,2	''
20—30	6,4	5,6	2,3	0,0	0,0	17,7	3,9	21,6	23,3	23,3	—1,7	''
30—40	5,5	5,7	1,4	0,0	0,0	16,4	5,3	21,7	22,4	22,4	--0,7	''
40—50	6,6	5,8	1,2	0,0	0,0	18,5	6,3	24,8	27,9	27,9	—3,1	''
50—60	6,8	6,1	1,1	0,0	0,0	19,1	5,5	24,6	26,6	26,6	—2,0	''
60—68	7,0	6,4	1,0	0,05	2,0	23,0	7,4	30,4	24,2	26	4	0,12
70—80	7,6	7,2	0,7	3,12	142	200	20	223	19,8	162	61	0,58
80—90	7,8	7,2	0,5	5,46	248	327	25	352	18,9	267	85	1,10
90—100	7,9	7,3	0,5	7,22	329	353	25	378	18,2	347	31	1,19
100—110	7,9	7,2	0,4	7,66	349	372	27	399	17,3	366	33	1,27
110—120	7,9	7,3	0,4	7,52	342	366	28	394	17,5	359	35	0,10
120—130	7,9	7,3	0,3	7,12	324	336	31	367	17,8	342	25	Not det'd
130—140	7,9	7,3	0,4	7,16	326	356	30	386	17,2	343	43	''
140—150	7,9	7,3	0,2	7,16	326	344	30	374	16,7	343	31	''
150—160	7,9	7,3	0,2	6,96	317	338	30	368	16,9	334	34	''
160—170	8,1	7,3	0,2	6,77	308	319	31	350	18,6	327	23	''
170—180	8,1	7,4	0,2	6,11	278	295	32	327	17,6	296	31	''
180—190	8,1	7,4	0,2	5,62	255	270	32	302	17,8	273	29	''
190—200	8,2	7,4	0,2	5,56	253	270	32	302	17,6	271	31	''

Note: Comma represents decimal point.

acetate solution as being the totality of the exchangeable forms of these cations dispaced by the ammonium ion, and carbonates of the same cations going into solution in the ammonium acetate. The dissolution of the latter is accompanied by a double exchange reaction:

$$2NH_4CH_3COO+CaCO_3 \rightarrow (NH_4)_2CO_3+Ca(CH_3COO)_2,$$

whereby the ammonium carbonate, in disintegrating, evaporates and the reaction procedes from left to right to the end.

The exchange capacity (column 10) was determined by the method of Bobko-Askinazi by first dissolving the carbonates in a solution of ammonium chloride. We avoided the use of hydrochloric acid for this on purpose in order not to cause the slightest destruction of the colloidal complex.

We determined the quartz content and the content of the oxide fractions both soluble and insoluble in a triacid extract (Table 4) by the method suggested by us in earlier works (3, 4), with the only difference that we calculated the content of bound (silicate) silicic acid and quartz in a simpler way. The content of alumina in the "main residue" of the extract we multiplied by a coefficient 360:102=3.53 in order to determine the content of bound silicic acid in the main residue, assuming that all of it is contained in the form of acid feldspar at a ratio $6SiO_2:Al_2O_3=360:102$. The content of bound silicic acid, thus found, was deducted from its total content in the main residue. We assumed that the difference between these two values gave the measure of the quartz content.

Let us examine the analytical data and turn to Figure 2, which is subdivided into six sections (A-F), each of which shows the variations of some element along the profile.

A humus horizon about 25 cm thick and containing 3%-2% humus stands out clearly on the humus distribution curve in section A. Further, its content decreases to 2%-1% to a depth of 70 cm and deeper it constitutes only tenths of a percent.

The carbonate carbonic acid content curve (section A, curve 2) shows a horizon leached of carbonates (0-70 cm), an illuvial-carbonate horizon (80-180 cm) with a maximum carbonate content in the layer from 100-120 cm, and the parent material with a CO_2 carbonate content of about 5.5% (layer from 180-200 cm), which deeper decreases to 4.5%, as determina-

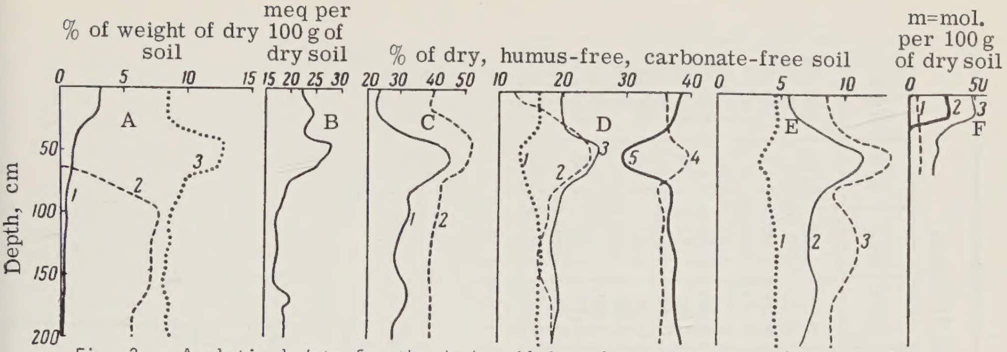

Fig. 2. - Analytical data for the dark soil in a large depression (Profile 19-a).

A - 1 - humus; 2 - carbonate CO_2; 3 - maximum hygroscopicity. B - exchange capacity. C. 1 - <0.001 mm diameter fraction; 2 - total of soluble oxides. D - SiO_2. 1 - insoluble; 2 - in the clay fraction; 3 - soluble; 4 - bound (silicate); 5 - quartz. E - Al_2O_3. 1 - insoluble; 2 - in the clay fraction; 3 - soluble. F - hot 5% KOH extract. 1 - Al_2O_3; 2 - amorphous SiO_2; 3 - SiO_2.

ns in deeper holes showed. This last value ould be considered as the CO_2 content in the il material.

The maximum hygroscopicity curve in sec- n A, as all other curves in sections B-E, ows evidence of the presence of a sharply-de- ied horizon at a depth from 30-80 cm in the il profile, which seems to be either the illu- l, or the clay forming horizon. As com- red to the overlying (0-30 cm) and underly- g (below 80 cm) layers, this horizon has e following distinguishing features: a high ximum hygroscopicity (Fig. 2, section A, rve 3); a high exchange capacity (section B); igh clay fraction[2] content and a high total of ides soluble in a triacid mixture (section C); ow quartz content; a slightly lowered content the bound silica fraction insoluble in the acid mixture; a high content of the silica frac- n soluble in the same mixture and silica ming part of the clay fraction; a slightly in- eased content of the entire bound silicic acid ction D); a high content of the alumina frac- n soluble in the triacid mixture and alumina tained in the clay fraction; a slightly decreased tent of the alumina fraction insoluble in the acid mixture (section E); a low content of total icic acid and a high content of alumina and ric oxide (Table 3).

Let us note that the horizon which has all se characteristics corresponds to the mor- logically "leached" cinnamon-brown horizon.

The first assumption which arises when one mines the above characteristics is that the en horizon is illuvial. Taking into account t the composition of the clay fraction hard- changes along the soil profile (Table 4), one y assume that the illuvial horizon had formed a result of the washing of undestroyed clay particles from the upper layers into it.

However, the formation of an illuvial horizon, be it by washing, or in any other way, must always be associated with the formation of an eluvial horizon above it. Precisely the latter is the source of those clay particles (during washing), or oxides (during the formation of an illuvial horizon in other ways), which move into the illuvial horizon. At first glance, judging by the distribution of the clay particles along the soil profile (Table 1), it seems that such a horizon is present in our soil. The clay particle content in the layer from 0-30 cm is only 25%-26% as against 30% in the parent material. The migration of precisely these 4%-5% of clay particles from the 0-30 cm layer toward the 30-80 cm layer could have, it seems, changed the first into an eluvial horizon and the second into an illuvial horizon.

However, besides the fact that such an amount of clay particles would not be sufficient for an illuvial horizon with a maximum clay particles content of about 45% (as may clearly be seen from an examination of curve 2, section C, Fig. 2) to form, there are other factors which attest to the impossibility of such a process. If the clay particles were leached from the 0-30 cm layer, this layer should have been poor in sesquioxides and rich in silica as compared to the parent material. It is well known that the silica content in the particles decreases as the particles size decreases, while that of sesquioxides increases. In our case the total content of these components in percent of the dry weight of the humus-free, carbonate-free material was in the fraction <0.001 mm in diameter, SiO_2, 56.6; Al_2O_3, 23.4; Fe_2O_3, 11.5 and in the fraction >0.001 mm in diameter, SiO_2, 79.7; Al_2O_3, 9.7; Fe_2O_3, 2.5, respectively.

Consequently, if a certain amount of clay particles had been really removed from the 0-30 cm layer, the silica content in this layer would have been higher and that of alumina or ferric oxide lower as compared to the parent material. However, as can be seen from Tables 3 and 5, the oxide contents, as well as that of their insoluble and soluble fractions, corresponds

---

The clay fraction content in section C is given in cent of the weight of the water-free fraction of weight of water-free, humus-free and carbonate- e soil and thus does not correspond to the values he content of this fraction in Table 1.

Table 3

Total chemical composition of dark chernozem-like soil in a large depression

Depth, cm	In % of dry soil weight					In % of water-free, humus-free, carbonate-free soil											
	hygroscopic moisture	humus	chemically bound water	CO_2 of carbonates	CaO of carbonates	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	SO_4	CaO	MgO	MnO	Na_2O	K_2O	Total
0—10	2,01	3,18	4,21	0,0	0,0	74,36	13,25	5,06	0,80	0,15	Traces	1,45	1,51	0,11	1,18	2,71	100,58
20—30	2,35	2,30	4,04	0,0	0,0	73,46	14,06	5,15	0,72	0,15	"	1,44	1,42	0,12	Not det'd.		96,56
30—40	2,25	1,41	4,93	0,0	0,0	71,10	15,06	5,85	0,71	0,18	"	1,32	1,70	0,11	1,06	2,72	99,81
40—59	3,03	1,19	5,56	0,0	0,0	69,07	17,26	6,70	0,77	Not det'd.	"	1,55	1,95	0,10	Not det'd.		97,40
59—60	2,89	1,07	5,55	0,1	0,0	69,26	16,22	6,89	0,73	0,15	"	1,10	2,05	0,10	1,01	3,02	100,53
60—68	2,72	1,01	4,64	0,05	0,06	70,42	15,56	6,40	0,78	0,15	"	1,07	2,11	0,10	1,07	2,91	100,87
70—80	2,38	0,67	5,00	3,12	3,97	71,56	13,24	5,94	0,70	0,18	"	2,79	2,36	0,09	1,17	2,70	100,73
80—90	1,93	0,50	5,42	5,46	7,20	71,52	13,84	5,50	0,82	Not det'd.	"	3,75	2,01	0,16	Not det'd.		97,29
90—100	1,83	0,48	3,52	7,22	9,18	71,84	14,86	5,42	0,69	0,19	"	1,56	2,18	0,20	1,21	2,60	100,75
100—110	1,77	0,43	3,37	7,66	9,75	72,37	14,96	5,20	0,83	Not det'd.	"	1,32	2,29	0,20	Not det'd.		97,17
120—130	1,81	0,30	3,13	7,12	9,06	72,56	15,60	5,08	0,71	"	"	0,65	2,48	0,20	"		97,28
140—150	1,81	0,24	3,18	7,16	9,11	73,27	14,56	4,85	0,76	0,14	"	1,09	2,47	0,19	1,32	2,58	101,23
160—170	1,74	0,22	3,30	6,77	8,61	73,27	13,78	5,25	0,66	Not det'd.	"	1,20	2,54	0,20	Not det'd.		96,90
190—200	1,75	0,23	3,46	5,56	7,07	73,63	13,71	5,11	0,63	0,16	"	0,88	2,52	0,19	1,37	2,52	100,72

Note: Comma represents decimal point.

Table 4

Total chemical composition of the clay fraction (particles <0.001 mm in diameter) of dark soil in a large depression

Depth, cm	In % of wt. of dry soil	In % of weight of ignited substance						Molecular ratio	
	ignition loss	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	Total	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{R_2O_3}$
0—20	16,74	54,97	23,88	10,43	1,29	0,41	90,98	3,92	3,06
40—60	11,32	55,23	25,26	11,52	1,23	0,11	93,35	3,72	2,88
80—100	11,32	56,10	24,22	11,14	1,25	0,25	92,96	3,93	3,04
120—140	10,82	56,45	24,69	10,99	1,35	0,05	93,53	3,88	3,02
150—170	10,97	56,40	24,36	10,92	1,21	0,12	93,01	3,93	3,06
180—200	10,10	56,61	23,40	11,50	1,19	0,15	92,85	4,10	3,12

Note: Comma represents decimal point.

Table 5

Quartz content and the solubility of certain oxides in a triacid extract from the chernozem-like soil of a large depression, % of the weight of water-free, humus-free, carbonate-free soil

Depth, cm	SiO_2				Al_2O_3			Fe_2O_3			CaO				MgO			
	quartz	insoluble	soluble	total	insoluble	soluble	total	insoluble	soluble	total	ex-change	in-soluble	sol-uble	total	ex-change	in-soluble	sol-uble	total
0—10	38,16	16,22	19,98	74,36	4,60	8,65	13,25	0,17	4,89	5,06	0,60	0,44	0,41	1,45	0,07	0,14	1,30	1,51
20—30	36,85	16,39	20,22	73,46	4,64	9,32	14,06	0,14	5,01	5,15	0,48	0,45	0,51	1,44	0,08	0,17	1,17	1,42
30—40	34,23	15,07	21,80	71,10	4,33	10,73	15,06	0,18	5,67	5,85	0,49	0,55	0,28	1,32	0,11	0,14	1,45	1,70
40—50	30,10	13,15	25,72	69,07	3,73	13,53	17,26	0,24	6,46	6,70	0,55	0,41	0,59	1,55	0,13	0,11	1,71	1,95
50—60	—	—	—	69,26	—	—	16,22	—	—	6,89	—	—	—	1,10	—	—	—	2,05
60—68	32,89	14,10	23,43	70,42	4,00	11,56	15,56	0,14	6,26	6,40	0,63	0,37	0,07	1,07	0,15	0,11	1,85	2,11
70—80	36,72	14,89	20,45	71,56	4,08	9,16	13,24	0,15	5,79	5,94	1,95	0,43	0,41	2,79	0,40	0,11	1,85	2,36
80—90	—	—	—	71,52	—	—	13,84	—	—	5,50	—	—	—	3,75	—	—	—	2,01
90—100	36,38	16,06	19,40	71,84	4,55	10,31	14,86	0,15	5,27	5,42	0,13	0,46	0,92	1,56	0,50	0,10	1,58	2,18
100—110	—	—	—	72,37	—	—	14,96	—	—	5,20	—	—	—	1,32	—	—	—	2,29
120—130	37,25	16,65	18,66	72,56	4,72	10,98	15,60	0,15	4,93	5,08	0,42	0,47	?	0,65	0,62	0,07	1,79	2,48
140—150	—	—	—	73,27	—	—	14,56	—	—	4,85	—	—	—	1,09	—	—	—	2,47
160—170	37,43	16,37	19,47	73,27	4,64	9,14	13,78	0,18	5,07	5,25	0,38	0,37	0,45	1,20	0,62	0,10	1,82	2,54
190—200	38,41	16,38	18,84	73,63	4,65	9,06	13,71	0,17	4,94	5,11	0,56	0,35	?	0,88	0,64	0,11	1,77	2,52

Note: Comma represents decimal point.

almost exactly to the content of all these elements, including that of quartz in the 0-10 and 10-20 cm layers, in the parent material. The same is true of the total content of that part of the soil which enters into the triacid extract (Fig. 2, section C, curve 2); its content is 39.7% in the layer from 0-10 cm and 39.5% in the layer from 190-200 cm. Since clay particles dissolve more easily than larger particles, and practically completely,[3] it seems that if they were removed from the 0-30 cm layer, the content of the fraction, soluble in the triacid extract, would have been much lower than in the parent material.

Micromorphological investigations also point to the absence of incrustations of the oriented clay substance in micropores and cracks, which are so typical of the illuvial process. Clay particles, aggregated in the form of small scales and fibers, as well as in the form of microconcretions, form discontinuous polarizing striae, often oriented along visible fine, predominantly vertical, but also horizontal, cracks. Such characteristics of the clay substance rather indicate, as Brewer (6) points out, that it formed in place, probably from the decomposition products of primary minerals. The partial orientation of its scales probably occurs under the influence of the alternate wetting and drying of the soil. The removal of clay from the upper layer is probably inhibited by the fact that it occurs in a coagulated state together with organic substances, saturated with alkaline earth cations.

It was not possible to compare exactly the amount of feldspar, which could have contributed to the formation of clay, in the various horizons on the basis of mineralogical analysis (Table 6), because in the method used by us for preparing the samples (repeated grinding without chemical treatment) from both the upper and the carbonate layer, small microaggregates were left containing fragments of primary minerals <0.01 mm in diameter. However, even these data show that the amount of feldspar in the layer from 50-60 cm is lower than that in the upper horizon, even though there are more microaggregates in the latter; in the carbonate layer they form part of the clay-carbonate microaggregates, which here amount to 30%.

From these facts we can make two conclusions. First, all the facts point to the impossibility of the washing of clay particles in any significant amount from the upper layer. Secondly, these facts indicate that the low content of clay particles in the upper layers is due to their aggregation into larger particles and not to their washing out.

The results of mineralogical analysis (Table 6) point to a high content of clay-humus aggregates in the humus horizon as compared to the underlying horizon. The latter are not destroyed under the peptization used in the preparation of soil for particle-size analysis, but enter into solution on treatment with the triacid mixture. This conclusion is also supported by the fact, as may be seen from Figure 2, section D, curves 2 and 3, that the content of silica, which is soluble in the triacid mixture, is in every case very close to its content in the clay fraction, except in the upper 10 cm layer, where much more silica enters the triacid extract (19.98% as against 12.8% in the clay fraction). Thus, the assumption that the horizon we deal with is of an illuvial nature is incorrect.

It remains to be assumed that this horizon is formed by clay formation in situ. In favor of this is the fact that the sum of fractions soluble and insoluble in the triacid mixture in the upper layer of the soil (0-30 cm) and its lower layers (120-200 cm) is similar, as may be seen from Table 7.

The increase in the content of total oxides which enter the triacid mixture in the 30-80 cm layer is due to the decrease of the content of substances not entering this extract, that is, because of the clay formation of large particles consisting, except for quartz, as usual, primarily of feldspars, and partly of other primary minerals.

Let us now examine the behavior of quartz in the soil profile. As we may see from curve 4, section D, Figure 2 and Table 4, the quartz content, being equal in the upper and lower layers (about 38%), noticeably decreases to 30% in the clay forming horizon. As with feldspar, we could not determine with sufficient accuracy the quartz content in the various horizons during mineralogical analysis. In the clay forming horizon it is lower than in the upper horizon; a sample taken from a depth of 150-160 cm gave a higher value.

If this horizon were illuvial, such a decrease in quartz content would have been quite natural and could have been explained by the absolute accumulation of clay particles and its consequence, a relative decrease in quartz content. But since we had to discard the possibility of the eluviation of clay particles, this explanation becomes invalid. The only explanation that can be offered is that quartz is subjected to dissolution and removal in this horizon, i. e., that it was completely lost. Such a partial loss of quartz was the cause of the relative accumula tion in this horizon of bound silicic acid and sesquioxides, which was found in total chemical analysis (Table 4). The offered explanation contradicts the accepted opinion about quartz as being a stable mineral in the process of weathering and soil formation. But there is no other explanation for the low quartz content in the clay forming horizon, and the view that quart is completely stable must be revised. The following indications in the existing monograph of Eiler (1) are also one of the reasons for doing it. Certain investigators came to the conclusion that the surface of particles of pulverized quartz is high disrupted, even amorphous.

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[3] In relation to the question of the solubility of the clay fraction in a triacid mixture it is notable that the silica content in the clay fraction, on the one hand, and the content of silica entering into the triacid extract, on the other, agree almost exactly, as it may be seen by comparing curve 2 with curve 3 in section D of Figure 2, i. e., almost all silica entering into the triacid extract is derived from the clay fraction, while the quartz content in the clay fraction is apparently insignificant.

Table 6

Mineralogical composition of 0.25-0.001 mm fractions of dark soil in a large depression (Profile 19-a) at Dzhanybek station, % of the entire soil

Depth, cm	Diameter of fraction, mm	Minerals									
		Heavy	Chlorite	Mica	Hydromica	Plagioclase	Potassium feldspars	Quartz and chalcedony	Opal (phytoliths, diatom skeletons)	Clay, organo-clay, carbonate-clay aggregates	Organic remains and humus
0—10	0,25—0,10	Single	—	—	—	0,16	0,02	0,08	—	—	0,01
"	0,10—0,01	1,15	0,10	0,63	0,34	22,99	7,83	15,80	0,49	5,75	1,32
"	0,01—0,001	0,61	0,68	0,38	2,35	4,41	1,90	0,93	3,23	13,98	1,33
	Total	1,76	0,78	1,01	2,69	27,56	9,75	16,81	3,72	19,73	2,66
20—30	0,25—0,10	Single	—	—	—	0,28	0,06	0,13	—	0,51	0,01
"	0,10—0,01	0,75	0,14	1,27	0,54	15,85	6,89	12,36	0,29	9,67	0,63
"	0,01—0,001	0,82	0,31	0,43	4,96	5,51	1,24	0,64	2,29	7,63	2,75
	Total	1,57	0,45	1,70	5,60	23,17	7,85	13,13	2,58	17,81	33,9
50—60	0,25—0,10	Single	—	—	—	0,28	0,03	0,14	—	0,09	Single
"	0,10—0,01	0,95	0,24	0,24	0,38	15,54	7,05	13,14	0,01	0,28	0,08
"	0,01—0,001	0,72	0,21	0,41	4,61	4,93	0,82	1,24	0,04	8,57	—
	Total	1,67	0,45	0,65	4,99	20,75	7,90	13,52	0,05	8,94	0,08
150—160	0,25—0,10	Single	—	—	—	0,19	0,11	0,14	—	0,09	Single
"	0,10—0,01	2,80	0,69	1,67	0,50	16,65	6,72	20,00	Single	Single	—
"	0,01—0,001	0,35	0,07	0,09	2,57	2,64	0,13	0,83	"	31,57	—
	Total	3,15	0,76	1,76	3,07	19,48	6,96	20,97	"	31,66	Single

Note: Comma represents decimal point.

Table 7

Sum of oxides which do not enter (I) and enter (II) into a triacid extract, % of water-free humus-free, carbonate-free soil

Depth, cm	I	II	Depth, cm	I	II
0—10	60,3	39,7	70—80	57,0	43,0
20—30	60,6	39,4	90—100	58,2	41,8
30—40	49,3	50,7	120—130	60,5	39,5
40—50	48,2	51,8	160—170	60,0	40,0
60—68	51,6	48,4	190—200	60,5	39,5

Note: Comma represents decimal point.

empster and Rich found that when pulverizing artz particles to 5-10 mμ, the concentration the non-quartz component increases noticely. On the basis of differential thermal alysis and the change in density, the thickness the changed layer is evaluated at 110-150 mμ. ob and others came to the conclusion that the amorphous layer on quartz is about 30-60 mμ thick.

In relation to this it must also be noted that Jackson and others (7) consider quartz to be more stable among the fine fractions (< 5 μ in diameter) of sedimentary rocks and soils than feldspar, but less stable than colorless mica (muscovite and illite).

The general character of the soil indicates that all soils, including those in the large depressions, underwent in the past a stage of weak salinization, which later changed into solonetzation and solodization.

One may think that the dissolution of quartz occurred during a stage of soil development when it was solonetz, or strongly solonetzized soil, and its reaction was predominantly alkaline. During this stage sodium carbonate contained in the soil, or periodically appearing in it, could have been the very agent which dissolved quartz forming part of the silt fraction, i. e., finely pulverized quartz. The clay forming horizon, in which this dissolution took place, was probably the former solonetz horizon in which the alkaline reaction and the presence of exchangeable sodium promoted clay formation. On the other hand, these phenomena were absent in the horizon overlying the solonetz horizon which retained the composition of the initial material in its mineral portion. It must also be noted that the alkaline reaction of solonetzes promotes the fragmentation of large quartz crystals (5).

The last thing that we have to examine are certain characteristics of the behavior of calcium. In the total chemical composition of the soil (Tables 3 and 4) we find a sharply increasing content of non-carbonate CaO in the 70-80 cm and 80-90 cm layers, i. e., the uppermost part of the carbonate horizon, which amounts to 2.79% and 3.75%, respectively. In the neighboring layers the CaO content reaches only 1.07% to 1.50%. These high calcium content values were verified twice. As may be seen from Table 4, the increased calcium content in the 70-80 cm layer (and probably the 80-90 cm layer for which similar determinations were not made) is entirely due to the high content of its "exchangeable" form, which reaches 1.95% calculated as CaO, while in the remaining layers the exchangeable calcium content, expressed in the same manner, does not exceed 0.2%-0.6%. The "exchangeable" calcium content was determined as the difference between the amount of calcium entering the ammonium acetate solution, on the one hand, and the carbonate carbonic acid, on the other. We assumed thereby that the soil contains only calcium carbonate; values referring to the magnesium content indicate that even if magnesium carbonate were contained in the soil, its amount is insignificant. These values for the "exchangeable" Ca content considerably exceed the exchange capacity values. Besides, in comparing the high total amounts of calcium oxide in the upper part of the carbonate horizon with data in Table 2, we can see that in this table they have a counterpart in the high values of the excess total amounts of Ca and Mg, entering into the ammonium acetate solution, over the total carbonate carbonic acid and the exchange capacity. This excess reaches 61 meq in the 70-80 cm layer and 85 meq in the 80-90 cm layer. Such an excess is also found in the lowerlaying layers, but it varies around 30 meq. What is the cause of such an excess? The assumption of the possible participation of simple calcium salts is invalid, since the total sulfate determination (see the last column in Table 2) revealed that they were present in very insignificant quantities. It may be assumed that in the layers below 90 cm, where this excess is smaller and more or less constant (close to 3 meq), it is due to the fact that during an alkaline reaction, which is characteristic of layers containing carbonates, the exchange capacity is higher than during such a weakly acid reaction as is used to determine the capacity by the method of Bobko-Askinazi. But even with such an explanation it remains obscure why the value of the foregoing excess is unusually high in the 70-80 cm and 80-90 cm layers of the upper portion of the carbonate horizon. Let us remember that an analogous phenomenon was first discovered by us in light-gray forest soil over the eluvium of calcareous rock in the Urals (Prasolov and Rode [2]). In this soil the excess reached 300 meq.

The assumption arose that this excess in the dark soil of the Great Depression is associated somehow with silicic acid. However, attempts to determine analytically silica soluble in alkaline extracts in the 70-80 cm and 80-90 cm layers both before and after the treatment of soil samples with ammonium acetate, gave very insignificant values of silicic acid. The search for silica in the ammonium acetate solution after it was used in the treatment of the soil was also negative.

Thus, the nature of the excess Ca and Mg content over the total exchange capacity and carbonate carbonic acid, which in the 70-80 cm and 80-90 cm horizons reached a great value, still remains unclear.

Table 8 gives the results of analysis of an extract made with a hot 5% solution of KOH by the method of Gedroyts, which are also shown in Figure 2, section F. This solution removed a considerable amount of silica and alumina from seven samples taken at intervals of 10 cm from the upper soil layers. On the basis of these data we calculated the content of amorphous silicic acid. In doing this we assumed that alumina appeared in the extract as a result of the dissolution of the clay fraction. To determine the amount of silica which entered the extract as a result of the dissolution of clay particles, we related it to alumina according to the formula:

$$3.9\ SiO_2 \cdot Al_2O_3,$$

proceeding from the composition of the clay fraction (Table 5). An excess of silica ("amorphous silica") was found only in the upper three layers, i. e., in the humus horizon which probably is the horizon which was formerly above the solonetz horizon, and which was subjected to a certain solodization. As may be seen from data in Table 6, it is represented by biogenic forms, primarily by gramineous phytoliths.

Conclusions

The morphological and analytical study of a profile of dark soil in a large depression shows that this soil possesses the following genetic characteristics.

Table 8

Composition of the 5% KOH solution extract and calculated content of amorphous silica in the dark soil of the Great Depression

Depth, cm	Extracted in hot 5% KOH solution				Content of SiO_2 bound with Al_2O_3 accord. to the formula 3.9 $SiO_2 \cdot Al_2O_3$	Remains free (amorphous) SiO_2	
	In % of dry soil weight		In millimoles per 100 g of dry soil				
	SiO_2	Al_2O_3	SiO_2	Al_2O_3	in millimoles per 100 g of dry soil	in millimoles per 100 g of dry soil	% of dry soil weight
0—10	2,92	0,54	49	5,3	21	28	1,68
10—20	3,00	0,52	50	5,1	20	30	1,80
20—30	1,81	0,59	30	5,8	23	7	0,42
30—40	1,18	0,84	20	8,3	32	None	—
40—50	1,25	0,94	21	9,2	36	"	—
50—60	1,09	0,78	18	7,7	30	"	—
60—68	1,08	0,68	18	6,7	26	"	—

ote: Comma represents decimal point.

1. The soil profile is divided into the follow- g horizons: a humus horizon, a leached (from rbonates) clay horizon, and a carbonate hori- n, which has an upper illuvial-carbonate sub- rizon.

2. The humus horizon is characterized by pronounced accumulation of biogenic forms amorphous silicic acid (primarily gramin- us phytholiths).

3. The leached clay horizon is character- ed by a high content of the clay fraction and lloids, a high total content of sesquioxides specially those soluble in a triacid misture), high maximum hygroscopicity, a high ex- ange capacity, and a low total silicic acid d quartz content as compared to the humus rizon and the parent material.

4. The formation of this horizon is due to clay rmation *in situ*.

5. The low content of quartz in this horizon ıst be attributed to its dissolution and re- oval during a stage when the soil was a lonetz, or was strongly solonetzic.

6. In the carbonate horizon, and especially its upper portion, an accumulation of cal- ım was found which entered into an ammonium etate solution when it was used to wash soil mples and the contents of which exceeded the al exchange capacity and the total amount of CO_2 carbonate. The nature of this excess lcium remains unknown.

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WATER-LOGGED FLOOD PLAINS AND METHODS OF THEIR RECLAMATION

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Attention has frequently been paid in party and state resolutions on the further development of agriculture to the necessity of using flood-plain lands. "Control figures on the development of Soviet agriculture for 1959-1965," ratified at the 21st meeting of the Communist Party of the USSR, provide for the extensive reclamation of flood plains for vegetable growing, since the soils in flood plains contain large amounts of nutrients required by cultivated plants (Table 1). Many flood plains, which have not been subjected to any special meliorative action, yield more vegetables and other crops to kolkhozes and sovkhozes than lands outside the flood plains.

But there are water-logged flood plains where the nutrients contained in the soil are not available to cultivated plants because of excess moisture, the development of anaerobic processes and the accumulation of organic substances in the soil. Conversion of water-logged flood plains into highly productive agricultural lands requires drainage, meliorative, and agricultural measures. In these flood plains the water regime and associated nutritional, thermal, air regime, and microbiological processes in the soil are unfavorable to the growing of vegetables, because of the prolonged inundation of the flood plains by spring and summer-autumn floods and the high ground-water level. A water regime which would meet the requirements of agricultural production is created by regulating the duration of the inundation of flood plains by flood waters, by lowering the ground-water level to the necessary depth, and by irrigating flood plains during dry years.

The water regime of flood plains should be regulated in conjunction with meliorative and agricultural measures. Meliorative measures prepare flood-plain lands for agricultural use by removing tree and shrub vegetation, removing stumps and roots, levelling the surface of the flood plain and by initial plowing and breaking up the sod.

Agricultural practices consists in tilling the soil, fertilizing and selecting crops and their varieties, and by distributing them among flood-plain elements, taking into account the fertility of soils. Agricultural practices used outside the flood plains should not be mechanically transferred to flood plains.

The use of water-logged flood-plain lands for vegetable growing requires their reclamation, considering the natural conditions of each flood plain, as well as individual areas of one and the same flood plain. All these measures should be directed toward the creation of fertile flood-plain soils to obtain high and consistent crop yields and ensure that the fields could be cultivated mechanically.

The same drainage measures should not be applied to various types of flood plains. The recently issued recommendations for the use of deep channels only to lower the ground-water level, for instance, or drainage to lower slightly this level, do not consider the nature of flood plains and very often do not provide for their necessary drainage. We suggest that flood plains be typed according to their natural conditions, the main type of water supply, and corresponding meliorative measures.

Water-logged flood plains may be divided into two groups: old lacustrine and low valley flood plains, and the groups into types according to the main type of water supply: alluvial (river), deluvial (slope), and ground or subsoil-runoff.

Water-logged, old lacustrine flood plains, as was already proved by Dokuchayev, were formerly old lakes. Their silting, overgrowth, and the formation of peat and sapropel took place under the active participation of flood, deluvial, ground, and subsoil-runoff water, which deposited mineral and organic substances derived from watersheds, and also as a result of biological processes.

Peat formation, which initially occurred in individual depressions, lakes, sinkholes and oxbows, now often embraces an entire flood plain. The way the rivers invade these flood plains (because of channel meanders, overgrowth by vegetation, silting, peat formation, and blockage) means that they do not really constitute proper water collectors. Flood waters inundate the flood plains for a long time, the water levels in rivers during the low water period are close to the surface and cause the ground water of the flood plains to rise.

The water-logged flood plains of this group differ from each other by the predominance of one of the mentioned type of water supply. The type of water supply is associated with soils,

Table 1

Content of main ash elements and nitrogen in the peat beds of water-logged flood plains, % of dry weight in the 0-20-cm layer (according to data of D. P. Meshcheryakov)

Bog	Ash	K_2O	CaO	Fe_2O_3	P_2O_5	SiO_2	SO_3	N	PH
Meadow	46,74	1,24	3,01	6,83	0,41	35,25	1,43	1,07	5,2
Alder	33,00	0,88	3,42	6,35	0,78	15,24	0,85	1,47	5,7
Sedge-tussock	18,60	3,78	4,44	4,26	0,55	6,04	1,51	1,85	6,5
Hypnum-sedge and hypnum	11,58	0,23	2,58	2,89	0,22	3,66	0,55	2,23	6,4
Transitional	12,29	0,12	3,33	2,12	0,26	4,58	0,50	2,70	5,8

Note: Comma represents decimal point.

eological structure, the nature of the relief, ne degree of mineralization of the waters enterng the flood plains, and vegetation. Old lacusrine water-logged flood plains include the flood lains of the rivers Dubna, Yakhroma, Sezhá, Istrom, Irpen', Nerussa, Kud'ma, Pekhorka, nd many others.

Water-logged low valley flood plains are haracterized by thick alluvial deposits consistng of river, flood, and oxbow deposits. The ivers of this group have well-developed chanels. The flood plains are wide and usually have ery pronounced stream-side, median, and errace-side flood plains. Relief forms under ne influence of flood water. With high floods nd sand deposition, the relief is crested, and ith clay deposits it is raised at the stream ide. Peat deposits are found primarily in oxows, flood-plain lakes and at the terrace-side, n areas where ground water comes to the surace. Excess moisture and water-logging of eat often result from flooding, or submersion, uring the construction of dams. Let us examine each type of flood plain and the corresonding drainage measures.

Old lacustrine flood plains fed by alluvial ater (type I). Excess moisture in these flood lains is caused by prolonged inundation by ood waters and the high level of ground water. here is either no, or very little, inflow of round water from slopes into the flood plain. round water is derived from flood water and mospheric precipitation. The relief of the ood plain is flat. The flood-plain lands const of peaty-bog and sod-meadow soils. Alder vamps and flood-plain meadows, rich in nuients, predominate. The duration of flooding id the high ground-water level in the flood ain are associated with the slow filtering cacity of the river channels and the high water vels in the rivers. Accelerated drainage of ood waters and the lowering of the groundater level may be achieved by regulating the ver and by digging closed, or open, channels divert the water from individual depressions d thalwegs of the flood plain, by regulating ibutaries, or by diverting them by means of land channels.

Upland channels should be used in peatvered flood plains when they are wide; they ould be connected at the upper and lower end with the river to ensure water supply from the river to the flood plain in case of fire and for irrigation in dry periods. An example of such a flood plain is that of the Kud'ma River, which flows into the Volga River below Gor'kiy.

The flood plain consists of several lake-like areas 300-4000 m wide, alternating with narrow areas. The relief of the flood plain is only slightly dissected. The steep right-bank slopes adjoining the flood plain are forested, while the left-bank slopes are plowed. Alder and meadow swamps with peat of various thickness (usually 2-3 m) occupy a considerable part of the flood plain. The water-logging of the flood plain was promoted by the prolonged stagnation of flood and raised ground water, which formed as a result of the saturation of soil materials forming the flood plain by flood water, atmospheric precipitation and the water derived from tributary rivers spreading over the flood plain in its individual sections.

The Kud'ma River is an unsatisfactory water collector, incapable of ensuring the timely drainage of flood water and of lowering the rising ground water in the flood plain. It was planned that the flood plain be drained by regulating the river by a dense, shallow drainage network with intervals of 50 m between channels designed for vegetable crops — 75-80 m for pastures, and 100 m for meadows.

When the project was put into effect all mills and fishweirs were torn down and the Kud'ma River was regulated by straightening its channel, and shortening its length by more than 40%; instead of varying slopes, ranging from 0.00004-0.00025, the river now has a single slope of 0.0005. Thalweg channels were dug in depressions, and upland channels in individual areas. These measures sharply changed the regime of the river and of the flood plain. The water levels in the river lowered by 130-140 cm during its existing period and the ground water in the flood plain dropped 0.4-0.8 m in early May, and 100 cm, later.

After the completion of drainage and melioration, high yields of agricultural crops were obtained in the flood plain. There is no need for a shallow drainage network. Floodgates in the river provide for irrigation during dry periods.

Consequently, flood plains of this type are drained by regulating the river, by establishing thalwegs (to divert the water from individual depressions) and by upland channels to intercept the water of tributaries and surface water from the catchment. These channels are used in dry periods to supply flood plains with water.

Old lacustrine flood plains fed by ground water (type II). Flood water remains longer on flood plains of this type than it is allowable for their agricultural use, and ground water collects from the catchment and stands close to the surface. Peat deposits form on sandy and sandy loam materials underlain by rocks. Permeable soil materials are also found on slopes and ground water flows along them into the flood plain.

Sedge-tussock, alder, or hypnum swamps predominate. Summer or autumn floods are very pronounced in these flood plains because of treeless water catchments with only slightly permeable soil materials and rather steep slopes. The flood plains of the Dubna, Tsna, Pekhorka, Sezha, Irpen' and other rivers belong to this type.

The main drainage measures include the regulation of rivers and the construction of trap channels for the interception and lowering of ground water derived from neighboring catchment basins. When the flood plains are wide and the inflow of ground water high, and when the ground water is not fully intercepted by trap channels, one, or several deep channels are dug in the lowermost areas to the depth of the permeable soil material underlying the peat deposits.

If it is impossible to lower the ground-water level in a flood plain enough for agricultural crops with deep but sparse channels (because of the high water levels in the river and the prohibitive cost of regulating it in order to greatly lower its level), a closed or an open drainage network is used, depending on the use to be made of the various portions of the flood plain. The foregoing measures ensure the timely drainage of flood water and the lowering of the ground-water level to the necessary depth. Let us cite an example of the reclamation of a flood plain of this type.

The Irpen' River, a right tributary of the Dnepr River, is 162 km long and has a catchment area of 335,000 km^2. The flood plain consists of a number of lake-like areas. The area assigned for reclamation is 9197 ha. Before melioration the flood plain was covered with shrubs and bog vegetation, while individual areas were used for hay.

The flood plain consists of alluvial deposits 2.5-12 m thick formed of sand, clay and clay loam on which peat has formed. About 90% of the area is occupied by peat soils. The causes for the water-logging of the flood plain were prolonged inundation by flood water, and the high level of ground water derived from slopes.

The flood plain was reclaimed by regulating the river channel and the channels of its tributaries (Unava, Bobritsa, Koska Rivers), and by the construction of a network of drainage channels, and mole drainage. The drainage channels are 1.2-1.5 m deep, about 1000 m long, and run along the river channel at a distance of 200-250 m from each other. The mole drains run perpendicular to these channels, are 0.8-1.0 m deep, and at a distance of 5-10 m from each other. The channels and drains divert excess water from the soil during the wet periods and are used for soil irrigation during dry periods. The latter is achieved by gravity by damming the rivers and channels, or with pump stations in the more elevated areas of the flood plain. Flood flow is regulated by water reservoirs in the upper reaches of the river and its tributaries.

Melioration measures ensure the regulation of the water regime of soils in accordance with the moisture requirements of agricultural crops during various periods of their growth.

Old lacustrine flood plains fed by ground and subsoil runoff water (type III). The causes for the water-logging of this type of flood plains are their excessively prolonged inundation with flood water and the cropping up, or capillary rise, and saturation of the flood-plain soil by ground and subsoil runoff waters derived from slopes. Because of the fact that the slopes adjacent to the flood plain usually consist of deluvial, only slightly permeable soil materials, deluvial surface water flows into the flood plain and intensifies the water-logging process. The ground and subsoil runoff waters flow into the flood plain along highly permeable soil materials, located between impermeable soil materials, and descending into the plain from slopes. Subsoil runoff water may well up in various areas across the flood plain through gullies, "funnels," or "windows" in the water-bearing layer of the deposits.

Flood plains of this type consist of peat and mineral alluvial and deluvial deposits. Peat occupies a considerable part of the surface of the flood plains, and ranges in thickness from 5-6 m and more in the "funnels" (for instance, it is 15 m thick in the "funnels" of the Yakhroma flood plain). Peat usually forms on slightly permeable soil materials. Sedge-tussock, hypnum-sedge, and meadow bogs, which are characterized by great fertility after drainage, predominate in flood plains of this type.

Flood plains of this type are drained by regulating the river channel and by constructing trap channels in areas where the ground water crops up, or where the piezometric pressure of the ground water currents is high. When the water-impermeable stratum covering the aquifer is very thick, the trap channels are provided with vertical wells into which water enters under pressure. It is very difficult to drain flood plains fed by ground and subsoil runoff water without intercepting the flow of subsoil runoff water and lowering its piezometric level. Deluvial waters derived from slopes are intercepted by upland channels which are dug at a higher elevation than the trap channels, or are combined with the latter if deluvial waters carry little sediment.

If these measures prove insufficient, deep channels should be dug along the flood plain so that water under pressure can flow into them through the funnels. In addition to these measur r reducing the water pressure, closed or open alweg channels are used along depressions and alwegs of wide flood-plains with strong sub-il water runoff. Closed drainage, or an open ainage network, should be used in the lower-ost areas with thick peat deposits, depending how the areas are to be used.

The flood plains of the Nerussa, Yakhroma, d other rivers belong to the type of old lacus-ine water-logged flood plains fed by ground d subsoil runoff water.

The flood plain of the Yakhroma River rmed where a deep lake was silted up with aterials brought in by deluvial, ground, and ood waters. The water-logged flood plain is ,500 ha, 30 km long, up to 8 km wide, and tends from the city of Dmitrov to the city of gachev.

It is characterized by a very complicated ological structure and complicated hydrogeo-gical conditions. Alluvial deposits, consisting sand, clay loam, a clay sediment, bog ore, at, and lime springs are underlain by orainic clay. Several water-bearing horizons rticipate in the feeding with water and water-gging of the flood plain, but the greatest im-rtance for melioration of the flood plain is ayed by the water of the pressurized Nadyur ter-bearing horizon contained in the aquifer nds between the impermeable morainic and rassic clays, and by waters of the present uvial horizon. The horizon under pressure very varied in the depth and thickness of the yers in which it is located.

The present alluvial horizon is found in sandy d clay loam deposits, and in peat beds. It fed by atmospheric precipitation, deluvial d flood waters, and the waters of the horizon der pressure. Its free level approximately incides with the surface of the flood plain. e excessive wetting of the flood plain resulted om the spreading of the water of the tributaries the Yakhroma River and from deluvial waters.

A considerable portion of the flood plain is cupied by peat deposits about 5 m thick, reach- a thickness of 15 m in funnels in morainic posits through which water under pressure lls up. The bogs of the flood plain include dge-tussock, meadow, alder, and hypnum-dge swamps. The flood plain may be divided o the following portions according to water pply and soil.

1. The low valley, river-side portion and uvial cones occupy about 50% of the area of flood plain. The soils are sod-gley, clay m, and sod-podzolic. Water supply is by rface, ground, and atmospheric water.

2. The central part occupies about 35% of area of the flood plain. It is flat and vered by peat-bog soils. It becomes inun-ed by flood water and the ground water is se to the surface.

3. The portion along the terrace occupies ut 10% of the area of the flood plain. It is ered by thick sedge-hypnum peats.

Water supply is primarily by subsoil runoff water. In addition, deluvial and ground waters are derived from slopes. The remaining portion of the flood plain is occupied by the riverbank and by outliers of an old eroded terrace. The soils are sod-gley clay loam on alluvial deposits, and the ground water is located at a depth of 1.3 m. Excess moisture causes the stagnation of surface waters.

The flood plain was drained several times. The river channel was regulated with the result that the duration of inundation of the flood plain was reduced and the water level in the river was lowered during the existing period. Upland trap channels were dug at the boundary of the flood plain and slopes, which intercepted the water of the tributaries and deluvial waters derived from slopes. A network of shallow open channels and partially covered drains were installed.

The experience of draining the Yarkhoma River flood plain showed that the regulation of the river and the construction of a shallow network alone without intercepting and lowering the subsoil runoff water by trap channels cannot ensure the drainage necessary for agricultural crops; excess soil moisture often leads to the lowering and even the loss of crops; in addition, a shallow open network interferes with the work of agricultural machines.

Old lacustrine flood plains fed by deluvial surface runoff (type IV). The surface of these flood plains consists of only slightly permeable clay and clay loam soil materials, similar to that of the catchment basin. Excess wetting is caused by the prolonged stagnation of flood and deluvial waters.

The clay and clay loam soil materials of the catchment basin and the dissection of slopes by ravines ensure the rapid runoff of of snow and shower waters from the slopes into the flood plain. The slightly permeable soil material, the flat relief, and the irregular surface of the flood plains, covered with vegetation, promote the stagnation of water in them and the formation of floods. As a result, autumn floods are very pronounced. The soils of the flood plains consists primarily of sod-podzolic clay and clay loam, underlain by clay sand. Peat formation is weak and limited to the terrace-side of the flood plains, rivers, oxbows, and areas where ground water comes to the surface.

Flood plains of this type are drained by channels regulating the river and by constructing upland to intercept surface water running down slope. Thalweg channels are dug in the depressions and thalwegs of the flood plain, which cut through the fine clay loam down to the underlying, highly permeable soil material. Drains are installed in depressed areas.

The flood plain of the Sestra River, a left tributary of the Dubna River, may be conditionally considered as such a flood plain. The length of the river is 156 km, the areas of the flood plain, 7000 ha. The area assigned for reclamation, which is located in the central reach of the river between the mouth of the Yamuga River and the village of Trekhsvyatsk, is 5143 ha. This valley occupies an ancient erosion ravine reaching a width of 5 km.

The alluvial deposits of the flood plain vary from 4-10 m in thickness and consist of sand, sandy loam, clay loam, clay, and peat. The main aquifer is the alluvial layer located at a depth of 0.5-3 m in fine-grained sand and sandy loam. It is underlain by impervious morainic clay loam.

The flood plain of the Sestra River differs from other water-logged flood plains (such as those of the Dubna, Irpen', and Yakhroma Rivers) in that it almost completely lacks peat. The soil of the flood plain consists of alluvial and deluvial clay loams. Peat deposits were found only in two places near the original river banks. Excess water areas are located throughout the flood plain and at the foot of slopes.

The main causes for the water-logging of the flood plain are flood waters and deluvial waters derived from slopes which stagnate in the flood plain as a result of the insufficient drainage capacity of the river channel, the low filtration coefficients of clay loams and fine sandy loams forming the flood plain, gentle slopes, and the presence of depressions, oxbows, and sinkholes. In addition, the excess wetting of the flood plain is caused by ground water derived in individual places from slopes, by the high river water levels during the low water period (because of dams of hydroelectric stations and mills), and ground water under pressure located in the flood plain at a depth of 0.5-3 m. But ground water and atmospheric precipitation play a secondary role in the water-logging of the flood plain.

Reclamation of the flood plain was achieved by regulating the Sestra River, by the installation of upland trap channels for intercepting the ground water from the original riverbanks and the construction of selected channels for diverting the water stagnating in depressions.

Low valley flood plains under prolonged inundation (type V). The flood plains are either permanently inundated by water reservoirs, or periodically inundated but unusable for agriculture.

The flood plains are characterized by thick alluvial deposits underlain by rocks. The alluvial deposits have formed as a result of deposition by river and flood waters. Peat deposits form on the terrace side and in areas where flood water stagnates, such as depressions, lakes, and oxbows. The duration of the flooding of various elements of the flood plain is not equal. Riverbanks are flooded for short periods, while the central flood plain is inundated for a longer period. Vegetation has a great influence on the movement of flood water and the deposition of material. The nature of the soil forming on various elements of the flood plains, and their fertility, vary.

The water regime of this type of flood plains is formed under the influence of atmospheric precipitation, and ground and deluvial waters, derived from neighboring slopes, in addition to flood water. Flood plains permanently flooded as a result of the construction of water reservoirs are drained by erecting dikes around them. Closed or open drains are constructed on the shore along the dikes to intercept the water filtering from the reservoirs and the flood plains are protected from the inflow of surface and ground water from slopes by upland, or collecting, channels. The water from the drainage network of the flood plains is emptied beyond the dikes by pumping stations, or by gravity into the lower water of the dam, forming the reservoir. When the flood plains are inundated for a long time and unusable for agriculture, they are drained by erecting submergible dikes by means of which the duration of flooding is regulated. When a flood begins to recede and reaches the level of the dike, the inflow of water into the flood plain ceases. The water left in the flood plain after the inundation is removed in a set time, by pumping stations, more rapidly than the river flood recedes. The flood plain is protected against the inflow of water from the catchment basin by upland and collecting channels in order to diminish the flow toward the pumping stations.

During the period when the flood plain is inundated by flood water the floodgates in the upland and trap channels are closed and the waters from the catchment basin are allowed to enter the flood plain to enrich it with nutrients. When the flood waters cease to inundate the flood plain the inflow of water from the catchment basin also ceases. The water remaining in the flood plain is removed by pumps as in the case of permanently inundated flood plains.

The erection of submersible dikes reduces the cost of embanking, ensures the deposition of nutrients contained in the flood waters in the flood plain, and the development of microbiological processes. Pumping stations should be constructed in such a manner as to supply irrigation water from the river, or reservoir, into the flood plain during dry periods, since the supply of soil moisture in the more elevated elements of the flood plain is often insufficient in certain years.

Low valley flood plains submerged flooding (type VI). The natural conditions, such as soils, relief, geological structure, and vegetation of these flood plains are similar to those of the preceding type, but differ greatly from them by their type of water supply.

Flood waters drain from the flood plain before the beginning of agricultural work, but the water levels in the river remain close to the surface and block the ground waters in the flood plain. The damming of the water in the river is caused by water reservoir dams and navigation locks. The high ground-water level causes the water-logging of the flood plain. If the damming of the river cannot be eliminated, the harmful effect of sub-surface flooding on the flood plain can be corrected by constructing a closed, or open drainage at a distance of 50-100 m along the river bank. The inflow of ground or surface waters from the catchment basin is intercepted by trap and upland channels constructed along the boundary of the flood plain. If these measures are not sufficient, deep channels are dug along the flood plain, or a close drainage or a network of open channels are used, depending on the intended utilization of the flood plain, and soil, geological, and other conditions.

Deepening, trap, river bank type, and other

Table 2

Types of water-logged flood plains and the principal methods of melioration

Types of water-gged flood plains	Geomorphology	Recommended measures	Depth, m
Old lacustrine lood plains fed y alluvial water	Formed where lakes or lake-like areas were. Peat is underlain by alluvial sandy deposits and occupies a considerable portion of the flood plain. Water-logging caused by stagnating flood water and high ground-water levels because the water collector is unsatisfactory. Alder swamps and submerged meadows predominate.	1. Regulation of the water supply. 2. Upland channels. 3. Thalweg channels.	2.5-3.0 1.2-1.5 1.2-1.5
Same, fed by round water	Same. Water-logging caused by the prolonged stagnation of flood water and the inflow of ground water from slopes. Sedge-tussock, alder, or hypnum-sedge bogs predominate.	1. Regulation of the water supply. 2. Upland trap channels. 3. In addition: deep channels cutting into the sand when the inflow of ground water is intense. 4. In addition: drainage, or an open network when the peat deposits are thick and the channels do not cut into the sand.	2.5-3.5 2.0-2.5 2.0-2.5 1.2-1.5
Same, fed by round and sub- oil-runoff water	Same. The flood plain consists of alluvial and deluvial deposits and peats underlain by fine clays. Water-logging caused by the stagnation of flood waters and ground water under pressure welling up through funnels in clay (up to 15 m deep), overlaying the water-bearing stratum, or rising by capillarities. Sedge-tussock, hypnum-sedge and meadow bogs predominate.	1. Regulation of the water supply. 2. Upland-trap channels, or vertical wells. 3. Thalweg channels 4. When the current of water under pressure is intense: deep channels, cutting into the sand 5. In addition when peat deposits are thick: drainage, or an open network	3-4 2.5-3 1.5-2 2.5-3 1.2-1.5
Old lacustrine, ed by deluvial vater	The flood plains consists primarily of clay deposits and peat deposits in depressions and oxbows only. Water-logging caused by the stagnation of flood and deluvial waters and atmospheric precipitation.	1. Regulation of the water supply 2. Upland channels 3. Thalweg channels 4. To accelerate runoff from individual areas: drainage, or an open network	2.5-3.0 1.5-2.0 1.2-2.0 1.0-1.5
Low valley, nder prolonged nundation	The flood plains are wide, with well-expressed relief elements. Alluvial deposits predominate; peat occurs in areas where flood water stagnates and where the ground-water level is high. The rivers are large with a well-developed channel; their regulation is not necessary.	1. Diking 2. Upland channels 3. Thalweg channels When the ground water is derived from the catchment basin: 4. Trap channels 5. Deep channels, or 6. A closed or open network 7. Diversion of water from the channels by gravity, or by means of pumping stations	1.5-2.0 1.2-2 1.5-2 2-2.5 2-2.5 1.2-1.5
Low valley lood plains with ub-surface looding	Same. Water-logging caused by the damming of river water by dams of hydroelectric stations, bridges, etc. Ground water is close to the surface.	1. River bank drainage With intense inflow of ground water from the catchment basin: 2. Upland-trap channels 3. Deep channels, or 4. Closed or open networks	2.5-3 2-2.5 2-2.5 1.2-1.5

Note: Flood-gates, runoff control in the catchment basin, sprinkling, etc., provide for the regulation of the duration of flooding, for the deposition of materials, and for irrigation during dry periods.

Hydrological melioration measures are carried out simultaneously with cultivation and agricultural practices.

inage channels are most effective when their toms cut into the sand underlying peat deposits.

The foregoing shows that the natural conditions of flood plains and the causes of their water-logging are very varied and no single method of drainage can be recommended. The effective use of flood plains for vegetable growing requires not only the timely drainage of excess surface flood waters, and the lowering of the ground-water level in order to stop water-logging, but also the regulation of the water, air, and nutrient regimes. It is well known that an excess, or deficiency, of soil moisture causes a decrease or loss of agricultural crop yields.

The excess water may be diverted from the soil, and deficient moisture for agricultural plants may be supplemented by hydrotechnical melioration. This is achieved by regulating the duration of the inundation of flood plains by flood waters, and by lowering or raising the ground-water level. Water is supplied to the soil in dry periods by damming the rivers, upland, trap and thalweg channels; by constructing water reservoirs on the river and its tributaries and supplying water from them to the flood plain; by irrigation and sprinkling along furrows, strips, etc.; and by supplying water from the river to the elevated elements of the flood plain by means of pumping stations.

The foregoing measures are used with consideration of natural conditions of the flood plain, requirements of agricultural crops, and soil moisture.

Damming greatly increases the productivity of water-logged flood plains when peat deposits are underlain by highly permeable soil materials and the flow of water in rivers and channels is continuous. At the same time the damming of channels (the bottom of which does not cut into the permeable soil materials underlying peat) is less effective. Damming should also be used on flood plains to regulate the duration of spring flooding to ensure the deposition on the soil of substances contained in the flood water and its enrichment in oxygen. To do that, dams with regulating flood-gates are constructed in the narrow sections of flood plains of the lacustrine type. The dam raises the flood water to a given level and lets it stand until it becomes light in color and enriches the soil with nutrients contained in it; then it is drained from the flood plain through flood-gates. This is repeated several times so long flooding is permissible. During floods the flood-gates in upland and collecting channels are closed and the water flowing down the slopes enters the flood plain throug the channels and deposits its material there. After a certain permissible period of flooding, all flood-gates in the river and in the mouths of the channels are open, while those in the upper sections of upland and collecting channels are closed, thus ensuring the rapid discharge of water from the flood plain and its drainage.

The soils in flood plains with a fully regulated hydrological and air regime will insure high and consistent agricultural crop yields in any "dry," or "wet" year in conformity with the requirements of agricultural production. Corresponding agricultural techniques must be used for increasing the productivity of flood-plain soils. High agricultural crop yields are obtained on drained flood plains; the yields of cabbage amount to 1000 cntr/ha; those of beets, 300-400 cntr/ha; of table carrots, 1000 cntr/ha; of forage beets, 1400 cntr/ha; of sunflower for silage, 1000 cntr/ha, and of silage corn, 500-900 cntr/ha. Table 2 shows the foregoing meliorative measures for various types of water-logged flood plains.

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NALITY OF GULLY EROSION IN THE EUROPEAN USSR

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t has been known for a long time that gullies n most intensively in spring during snow ting or in summer during continuous heavy s and especially downpours. This is why y erosion has been attributed first of all to iatic conditions and through them to other ral zonal features (soil and vegetation). s the idea of zonality of gully erosion came existence.

he concept of the zonal nature of gully ero- has been most clearly formulated by Berg According to him, the desert zone, where tered vegetation does not protect the soil n washing by melting snow and rain water, iost favorable to the development of gullies. steppe zone with its characteristic down- precipitation is also greatly subject to y erosion in spite of dense herb vegetation. forest zone is least favorable for gully for- ion. Referring to Tanfil'yev (47), Berg te "Forests are not conducive to the develop- t of gullies and the presence of gullies in the st zone and in forested areas of the forest- pe zone indicates that different conditions vailed here in the past, namely steppe con- ns" (4, p. 301).

. S. Kozmenko (18) also pointed out that be- se of forest vegetation, which almost com- ely checks the development of the erosion ess, the network of gullies is several times dense in the forest zone than in the steppe . The foregoing opinions relate to the in- nce of natural conditions, such as natural tation of various zones, on the development llies. The same is true of cultivated s. Thus, an idea of varying degrees of -danger in different natural zones is cre- .

he opinion that the steppe zone is favorable e development of gully erosion and that the st zone is unfavorable to it seems to be tantiated by the actual differential distribu- of gullies in these zones. Erosion maps and -distribution maps of the USSR, as a whole, of the European USSR, in particular (7, 21, 9, 46), show a fair agreement between the daries of intense gully development, the daries of the steppe and forest-steppe s, and the weak development of gullies be- their limits. Data on the development of erosion in the forest zone are very scant lmost non existent for tundra. The foregoing facts are insufficient for proving the zonality of gully erosion.

Differences in the distribution of gullies in various zones may be determined not only by zonal, but also by non-zonal natural factors, such as geological conditions, relief and their different economic use. The boundaries of the area with intense gully development agree just as well with, for instance, the limits of intense agricultural use as with those of natural zones. We would arrive at the same conclusions if we should compare areas with the greatest distribution of developing gullies with regions having the greatest development of easily eroded loess-like material, or areas with the highest and most dissected relief. How then can the relative importance of zonal factors in the development of gully erosion be determined? We made an attempt to answer this question by comparing gully erosion in areas not reclaimed by man in various natural zones and as similar as possible in their geological structure and relief. With this object in mind, we thoroughly studied the literature on the development of gully erosion in all natural zones and aerial photographs of individual representative areas in these zones. In addition, we studied gullies in the following localities: in the tundra — in the region of Vorkuta and Salekhard; in the forest zone — in individual plots along the banks of the Northern Dvina, the Ob' and the Irtysh Rivers; in the forest-steppe zone — in the Streltsk and Kazatsk virgin steppes and also in the Balagansk steppe in the Irkutsk Region; in the desert — on the southern and western cliffs of the Ust'-Urt. As a result, we were able to make the following conclusions: first, gully erosion is common not only to the steppe and forest-steppe zones (13, 25, 33, 37, 39, 41 and others) but also to all other natural zones. In the tundra, for instance, gullies are found at Kanin (1), and Kolguyev (6) in the Malozemel'sk and the Bol'shezemel'sk tundras (19, 22), in the Gydansk tundra (12), in the lower reaches of the Ob' (20) and the Yenisey (48) Rivers, in the Taimyr Peninsula (30, 35, 44, 45), in the lower reaches of the Khatanga and the Lena Rivers and also on the islands of the Arctic Ocean (15). In the forest zone of the European USSR, gullies are extensively developed in certain districts of Belorussia (51) and Ukraine (3, 33, 37, and others), along the valley slopes of the Volga, Western Dvina, and Dnieper Rivers and their tributaries (49). Gullies are also greatly developed in certain districts of the Kalinin (8), Moscow (14), Kostroma, Ivanovo, Yaroslavl', Vladimir, Gorkiy (27, 36), and Kirov Regions (50), as well as in other regions. In deserts, gullies are found along the cliffs of the Ust'-Urt (32, 42) and other tablelands, in the valleys of recent (24) and ancient (17) rivers, in the foothills of the Kopot Dagh (5) and Tyan'-Shan'. Secondly, gullies occur extremely rarely in areas that have not been reclaimed by man in all natural zones, including in the steppe and forest-steppe. As compared to reclaimed areas, natural gullies are rare in all zones, usually dissecting only narrow areas along steep riverbanks. In most cases their present rate of growth is very slow. There is no significant difference in the occurrence of gullies in various natural zones (natural gully erosion) under similar non-zonal conditions (relief, geological conditions).

Finally, our third conclusion is that the difference in the distribution of gullies in various zones, which could be attributed to zonal factors (climate and vegetation) is usually less pronounced than the differences resulting from non-zonal natural factors (geological structure and relief) and the characteristics of economic land development. Thus, for instance, under natural conditions in the tundra, recent gully erosion is encountered much less frequently than in the forest zone. But in reclaimed areas of the tundra (for instance, in Salekhard), gully erosion is often more pronounced than in cultivated areas of the forest zone (for instance, in Khanty-Mansiysk) because of the difference in the geological structure of these areas (i.e., a non-zonal factor). Even though natural gully erosion in semi-deserts and deserts is weakly developed it is nevertheless more pronounced than in non-cultivated areas of the steppe zone. However, in reclaimed steppe areas consisting of loess-like material it is much more widely distributed than in reclaimed areas of clay deserts. In plowed areas along the Northern Dvina, Don, and Volga Rivers, extending through different natural zones, one can very often observe that because of geomorphological (high and low banks) and geological differences, gullies develop much more weakly under favorable zonal conditions (climatic and soil-vegetation) than under adverse conditions.

From the foregoing, it follows that even if zonal factors play a definite role in the distribution of gully erosion they are far from being always of a decisive importance. Very often their role is subordinated to that of non-zonal factors, especially the anthropogenic factor.

This applies not only to the distribution of gullies but partially also to the intensity of their growth. Both these aspects of gully erosion usually attract special attention because of their practical importance. However, they do not present a complete picture of this phenomenon as a whole, in particular, such important aspects as the mechanics of gully formation and the phases of its development. These aspects of gully erosion are under a much greater influence of zonal factors.

As we know, the mechanics of gully erosion present a complex erosion-denudation process. It consists not only of water erosion but also of many non-erosion processes, which play an even more important role than water erosion proper, especially during the initial and final phases of gully formation. These processes include, for instance, the collapse, creep and crumbling of slopes and summits, as well as nivation, thermal erosion and solifluction, suffosion, karst, and others (2, 9, 10, 11, 13, 16, 2 23, 25, 28, 29, 30, 31, 33, 34, 35, 38, 40, 41, 43, 44, 45, and others).

The type of gullies, the rate of growth and the sequence of development greatly depend on the interrelation between erosion and non-erosion processes involved during the formati of gullies. This interrelation differs considerably from zone to zone. The characteristic features of the process of gully formation in th tundra, for instance, are related to frost fissu ing and solifluction; in the forest zone and partially in the forest-steppe zone, to creep processes; and in the arid steppe and desert zones to processes of suffosion, deflation, etc.

Zonal conditions affect the stage developme of gully formation to the same degree. Under the influence of the climatic zonality and associated characteristics of the development of vegetation, gullies in various zones acquire features characteristic to various stages of development of the gully formation process. In this respect, gullies found in the desert and tundra zones are especially unusual. The former have many stable features characteristic of gullies in the phase of morphological youth, such as, for instance, bare and steep slopes, stepped channels and steep drops at the summi of the gully. At the same time frequently such gullies have already practically stopped growin Gullies in the Arctic tundra are characterized by features typical of mature and old forms of erosion such as smooth thalweg profiles and comparatively gentle, slightly sodded slopes. Even very young, recent gullies rapidly acquir these features under the influence of solifluctio Their present growth, however, while it is usually insignificant, is nevertheless probably more intense than that of desert gullies which, judging from their outward appearance, are in a different, much earlier phase of developmen

One cannot but notice the importance of the foregoing zonal distinctions in the types of gullies and their course of development for the theory of stage development of erosional forms and their classification. The existing concept of the stage of gully erosion requires considerable correction because gully features characteristic for at least some of their stages of development are quite different in different geographic zones and areas. This fact has also a certain importance as far as practical measur for gully control are concerned. Because of zonal characteristics, gullies with similar mo phological features may be in different stages development and grow with a different intensit As a result, different measures should be take in their control.

Conclusions

Present zonal conditions (climatic, soil, vegetation) have a differential and unequal effect on various aspects of the process of gu ly erosion.

Their effect is most pronounced on the
chanics of gully erosion and the course of the
ge development of gullies. Their influence is
s on the intensity of growth of gullies and
en less on their distribution. The intensity and
tribution of gully erosion are much more
sely related to non-zonal natural factors (geo-
ical structure and relief), as well as to the
ure of the economic utilization of a given area.

The zonal nature of the danger of gullies
uld, therefore, not be unduly emphasized. In
s respect there are no safe zones. Under non-
al natural conditions favorable to erosion (re-
f and geological structure) and not overlooking
d use, all natural zones may become liable to
ly formation.

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OCESS OF SALT ACCUMULATION IN SOILS THE SOUTHERN BUG FLOOD PLAIN

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n planning the reclamation of water-logged od plains of the Southern Bug, the Odessa nch of the Ukrainian State Institute for Plan- Water Economy paid special attention to process of salt accumulation in flood-plain ds.

The development and attenuation of this proc- , and desalinization are directly dependent ydrological and hydrogeological factors. These in their turn, are determined by the geomorphology of the flood plain and the development of its relief. This was checked by us in the area of the flood plain designed for meliorative action extending from the rock outcrops near the village of Aleksandrovka in Voznesensk district to the village of Kasperovka in Novoodessa district. Below this area the water-logged flood plains are inundated by flood water during such a long period of time that their melioration

Table 1

Results of particle-size analysis of soils of the Southern Bug flood plain, % (pipette method with pre-treatment of samples with HCl and boiling with NaOH)

rofile No.	Depth, cm	Diameter, mm						
		>0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005— —0,001	<0,001	<0,01
	Domaniyev water-logged flood plains. Right bank, upper stretch							
1	0—20	0,50	21,66	51,20	11,04	10,64	4,94	26,64
	60—80	0,30	23,86	43,20	11,04	16,80	4,80	32,64
	Yastrebinovo water-logged flood plains. Middle stretch							
2	20—40	—	16,56	35,04	14,16	8,96	25,28	48,40
	60—80	—	18,60	35,24	5,44	14,32	26,40	46,16
	Novoandreyev water-logged flood plains. Lower stretch							
15	0—20	0,18	1,00	30,91	49,93	6,85	11,13	67,91
	60—70	0,47	0,95	23,34	38,95	9,01	27,28	75,24
	100—110	Peat		—	—	—	—	—
	Voznesensk water-logged flood plains. Left bank, upper stretch							
11	6—22	1,01	25,45	37,66	29,27	3,01	3,60	35,88
	129—133	1,12	27,52	35,25	29,74	4,0	2,37	36,11
	Domashev water-logged flood plains. Middle stretch							
20	0—20	0,08	4,79	45,30	36,83	5,62	7,38	29,83
	50—60	0,12	8,47	47,46	29,80	6,45	7,70	43,95
	110—120	0,06	3,01	40,48	41,08	5,34	10,08	56,50
	Novoodessa water-logged flood plains. Lower stretch							
8	0—20	0,29	1,68	24,59	59,00	7,22	7,32	73,54
	30—40	0,42	2,89	21,35	52,80	9,57	12,97	75,34

Note: Comma represents decimal point.

is not warranted, it is hindered by the low position of the water-logged flood plains relative to the river.

Alluvial processes had played a tremendous role in the evolution of the relief. This can be seen from the fact that alluvial deposits 2-3 m thick immediately overlie the crystalline rock in the upper reaches (village of Bogdanovka, Domanev district), while buried peat is found in the lower reaches (water-logged flood plains of Novoodessa). The difference between the absolute elevations of the upper and lower reaches of the given stretch of the river reaches 11 m, and this is the cause of the different hydrological conditions.

In the lower reaches the water-logged flood plains are inundated for a longer time than in the upper reaches, and, in addition, they are subjected to wind tides from the Dnepr-Bug estuary. Relief develops not only in the direction of the river current, but also transversely, from the river toward the original bank.

The structure of the Southern Bug flood plain is typical of the flood plains of steppe rivers. A narrow ridge runs along the river. A depression begins at the ridge, being deepest at the flood-plain terrace. The flood plain may be divided into three parts: along the river, median, and along the terrace. The ground water is located at a depth of 0.3-1.5 m in the lower reaches and at more than 2 m in the upper reaches. The sources of ground water recharg include the surface and ground waters of the original bank, and river and flood waters. The importance of one or the other factor is determined by the degree of relief development; the higher its development, the smaller is the role of flood and river waters. The ground-water discharge into the river is also determined by the degree of development of the flood plain. The water-logged plains rise 3-5 m above the river in the upper reach, and 0.3-0.5 m in the lower reaches.

The absolute ground-water levels in the lowe reaches are lowest in the central part of the water-logged flood plains. Consequently, there is no discharge of ground water here and the water balance must be regulated primarily by evaporation and transpiration. There is a distinct discharge into the river in the upper reaches. It must have an important part in the water balance.

Table 2

Results of particle-size analysis of soils of the Yastrebinovo and Doroshev water-logged flood plains, % (pipette method with pre-treatment of samples with HCl and boiling with NaOH)

Profile No.	Depth, cm	Diameter, mm						
		>0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	<0,001	<0,01
Doroshev water-logged flood plains. Along the river area of the flood plain.								
3	20—54	—	26,64	41,28	4,32	9,20	18,56	32,08
	120—140	—	30,00	40,32	3,92	10,00	15,76	29,68
Central part of the flood plain								
2	20—40	—	17,92	40,88	8,56	7,92	24,72	41,20
	60—80	—	17,20	32,96	10,24	12,32	27,28	49,84
Along the terrace area of the flood plain								
1	0—21	0,10	16,32	26,00	14,88	13,92	28,80	57,60
	21—59	0,40	12,88	25,84	10,88	9,28	30,72	50,88
Yastrebinovo water-logged flood plains. Along the river area of the flood plain.								
15	0—20	49,8	35,9	8,9	2,2	1,3	1,9	5,4
	40—60	46,4	35,9	12,7	1,0	2,0	2,0	5,0
	80—100	38,9	42,9	12,0	2,4	1,8	2,0	6,2
Central part of the flood plain								
17	0—20	9,4	29,8	46,0	7,7	5,9	1,2	14,8
	40—60	10,6	18,3	56,8	8,5	2,8	2,9	14,4
	80—100	7,8	22,5	55,6	7,0	2,7	2,1	11,8
Along the terrace area of the flood plain								
21	0—20	4,9	46,6	26,2	3,7	12,3	6,3	22,3
	40—70	4,0	33,0	36,3	8,3	10,7	7,5	26,5
	70—100	3,9	44,0	22,0	8,7	9,5	11,9	30,1

Note: Comma represents decimal point.

Table 3

Results of determinations of hydrophysical properties of soils in the Southern Bug flood plain

Water-logged flood plains	Depth, cm	Porosity, % of soil volume	Ultimate field moisture capacity, % of soil weight	Non-aerated porosity, % of total porosity	Water yield coefficient	Maximum molecular moisture capacity, % of weight	Total moisture content, m³/ha	Total available moisture, m³/ha	Permeability coefficient, cm/sec.
pper stretch, Domanev	0—20	48	28	75	0,12	15,3	—	—	0,00054
	20—40	48	29	79	0,10	14,8	—	—	—
	40—60	49	27	71	0,17	14,8	—	—	—
	60—80	49	26	69	0,15	15,8	—	—	—
	80—100	50	26	62	0,17	14,7	—	—	—
	0—80	48	27	73	0,14	15,2	2800	1,200	—
	0—100	49	27	72	0,14	15,1	—	—	—
ug area	0—20	53	29	64	0,18	15,2	—	—	0,00036
	20—40	46	28	81	0,09	15,6	—	—	—
	40—60	52	32	77	0,12	15,8	—	—	—
	60—80	50	32	80	0,10	15,9	—	—	—
	0—80	50	30	76	0,12	15,8	—	—	—
iddle stretch, Yastrebinovo	0—20	55	36	76	0,13	18,5	—	—	0,00024
	20—40	52	35	83	0,09	18,1	—	—	—
	40—60	51	34	84	0,08	19,1	—	—	—
	60—80	51	34	83	0,08	16,1	—	—	—
	0—80	52	35	82	0,09	18,0	3400	1650	—

Note: Comma represents decimal point.

The water regimes of the upper, central,
lower parts of the flood plain, which differ
m each other, determine the difference in
formation: with ample water supply the bog-
nchak process of soil formation predomi-
s in the lower reaches, the meadow-solon-
k process, in the central reaches, and the
dow-chernozem process, in the upper reaches.

oil varieties differ from each other by their
ure and the degree of salinization. The tex-
varies from sandy loam to fine clay loam
clay, and the degree of salinization from non-saline and weakly saline to strongly saline and solonchaks. The following patterns are found: the texture of the soils becomes finer down river (Table 1).

The texture of soil changes not only down river, but also in a direction away from the river toward the original bank. The following pattern is found here: along the river the area is represented by a coarser textured soil, while in the depression areas, it is represented by finer-textured soils (Table 2).

Table 4

Data on mineralization of recharge sources of ground waters in the Southern Bug flood plain, mg per liter

Sampling place	HCO_3^-	Cl^-	SO_4^{--}	Dry residue
round waters of original bank, rice-growing station	268	213	1200	2834
he same	375	44	120	3795
he same, Ryumenskoye village	380	92	265	—
he same, Dmitriyevka village	355	71	255	—
lood-plain terrace, rice-growing station	205	53	229	704
outhern Bug River near Yastrebinovo village	285	18	46	364
lood waters	174	17	60	370

Table 5

Results of determinations of the CO_2 carbonate content in soils of various water-logged plains, % by weight

Depth, cm	Yastrebinovo water-logged flood plain: Along the river	Central	Along the terrace	Depth, cm	Voznesensk	Chervono-Mayak
	Flood plain				Water-logged flood plains	
0—10	2,4	2,3	0,72	0—20	1,74	20,7
20—40	2,2	2,0	0,66	20—40	1,67	21,2
40—60	2,1	1,6	0,80	40—70	1,67	21,5
60—80	2,0	1,9	0,84	70—100	1,57	25,9
80—100	1,7	2,8	0,92	—	—	—
100—120	—	2,2	—	—	—	—
120—150	—	2,8	—	—	—	—

Note: Comma represents decimal point.

Sharp increased quantities of physical clay in soils of the lower reaches lead to changes in moisture and physical properties: increased porosities, decreased coefficients of permeability and water yields, increased limits of field moisture capacity, maximum molecular moisture capacity, total moisture content, and total available water (Table 3).

Thus, the difference in the elevation between the lower and upper parts of the water-logged flood plains, caused by the evolution of the relief of the flood plain, creates unequal conditions for the discharge of ground water from the flood plain into the river. In the upper part discharge is certain, while it is lacking in the lower part. The development of the flood-plain relief leads to the improvement of natural drainage, which is absent in the lower reaches. The reduction of the permeability and water yield of the flood-plain soils in the lower reaches impairs soil drainage.

Conditions are created in the lower and central reaches which are favorable for salt accumulation in the soil and in the ground waters. With an improvement of drainage in the upper reaches, the process of salt accumulation diminishes and is replaced by desalinization. This is confirmed by our data.

Table 6

Results of analysis of ground waters in Yastrebinovo water-logged flood plains, mg per liter

Part of the flood plain	HCO_3	Cl	SO_4
Along the river	556	22	56
Central	1300	6200	3000
Along the terrace	62	710	940

The sources of salt accumulation in the soil and ground waters of the Southern Bug flood pl include the ground waters of the original bank. They are weakly mineralized and sometimes fresh (Table 4).

The participation of the ground waters of the original bank in the supply of salts to the flood plain is indisputable. They wedge out along the entire flood plain and their mineralization is higher than that of the other sources.

The bicarbonate river waters also participa in salt accumulation. Their role in this proces may be judged by the deposition of calcium and magnesium carbonates. Their content along th river and central portions of the flood plain is higher than along the terrace portion. Thus the content of CO_2 carbonates in the soil of the Yastrebinovo water-logged flood plain, which is located closer to the river, is 2%, while along th terrace it is less than 1%. Such a distribution of carbonates in the soil in the direction from t river toward the original bank indicates their river origin. When water evaporates and salts concentrate as a result, the first to precipitate are calcium carbonates formed from bicarbonates. Consequently their maximum accumulati must take place immediately after the source o salt accumulation begins to flow into the flood plain. In this case the maximum amount of carbonates is found near the river, and not near th flood-plain terrace as it should have been if the main quantity of these salts were brought by ground waters from the original bank.

It is only natural that the participation of the river in salt accumulation decreases with relief development, this is why the carbonate content in soils must be higher in the lower reaches than in the upper. Actually, the CO_2 carbonate content in the flood plain soils of the Timiryazev sovkhoz (Chervono-Mayak water-logged flood plains) in the middle stretch reaches 25%, while in the upper stretch in the soils of the Dorurs sovkhoz (Voznesensk water-logged flood plains) it reaches onl 1.7% (Table 5).

Table 7

Results of analysis of water extracts from soils of Yastrebinovo and Chervono-Mayak water-logged flood plains, meq per 100 gm of soil

Place where soil samples were taken	Depth, cm	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	$Na^+ + K^+$ by difference	Total ions
Yastrebinovo water-logged flood plain, along the river area	0—20	0,59	0,14	0,42	0,85	0,3	None	2,30
	20—40	0,44	0,20	0,42	0,70	0,3	0,06	2,12
	40—70	0,39	0,20	0,44	0,65	0,3	0,08	2,06
	70—100	0,39	0,14	0,58	0,75	0,3	0,06	2,22
Central part	0—20	0,44	1,50	2,71	1,50	1,56	1,59	9,30
	20—40	0,51	1,38	3,65	2,50	0,82	2,22	11,08
	40—70	0,39	1,13	3,04	1,75	1,75	1,06	9,12
	70—100	0,39	1,01	4,92	1,80	0,92	3,60	12,64
Along the terrace area	0—20	0,39	1,04	2,33	1,55	0,88	1,33	7,52
	20—40	0,44	0,88	2,42	1,28	1,07	1,39	7,48
	40—70	0,33	0,88	1,64	1,18	0,88	0,79	5,70
	70—100	0,26	1,01	1,79	1,22	1,00	0,84	6,12
Chervono-Mayak water-logged flood plain, along the river part	0—20	0,88	1,47	0,71	0,70	0,40	1,96	6,12
	20—40	0,80	1,13	0,48	0,60	0,50	1,31	4,82
	60—80	0,82	0,79	0,23	0,60	0,30	0,94	3,68
Central part	0—20	0,56	13,09	2,77	1,80	2,00	12,62	32,84
	20—40	0,66	6,04	1,00	0,90	1,10	5,70	15,40
	60—80	0,92	2,20	0,50	0,20	0,50	2,92	7,24
Along the terrace area	0—20	1,30	0,17	0,12	0,30	0,50	0,79	3,18
	20—40	0,92	0,11	0,04	0,20	0,60	0,27	2,14
	80—100	0,75	0,11	0,08	0,30	0,30	0,34	1,88

Note: Comma represents decimal point.

The salinity of the ground waters of the flood ain is higher than at their source. The in- ease in mineralization is associated with the t that the main factor in ground-water losses re is evaporation. Their discharge is insigni- ant because of poor drainage. The least neralized ground waters are those along the er and also in the depressions along the ter- ce flood plain; their mineralization in the central part is high (Table 6).

The salinity of ground waters depends on the drainage of the flood plain: the lowest salt content is found in the part of the water-logged flood plain adjoining the river. With a correspondingly favorable relationship between the surface of the land and the river level, allowing for the discharge of ground waters, the latter serves as

Table 8

Results of analysis of ground waters of the Southern Bug water-logged flood plains, mg per liter

Water-logged flood plains	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	$Na^+ + K^+$	Total salts
Upper stretch								
Bug	43	522	62	130	180	60	13	1010
Voznesensk	29	414	61	30	100	30	60	724
Middle stretch								
Doroshev	53	1186	340	280	110	15	650	2654
Belousov	87	927	5500	1500	900	200	3220	12334
Lower stretch								
Novoandreyev	—	309	93	31	80	6	89	608
Andreyev	—	298	32	40	70	6	61	507
Kovalev	—	432	100	53	80	15	133	813

Table 9

Results of analysis of water extracts from soils of the Southern Bug flood plain, meq per 100 gm of soil

Water-logged flood plains	Depth, cm	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	$Na^+ + K^+$	Total ions
Upper stretch								
Domanev	0—20	0,54	0,23	0,16	—	—	—	1,86
	20—40	0,56	0,29	0,21	—	—	—	2,12
	40—70	0,56	0,11	0,25	—	—	—	1,84
	70—100	0,61	0,23	0,41	—	—	—	2,50
Bug	0—20	0,84	0,56	0,67	1,1	0,80	0,17	4,14
	40—70	0,79	0,40	0,54	0,90	0,30	0,53	3,46
	100—120	0,92	0,34	0,44	0,60	0,70	0,40	3,40
Middle stretch								
Yastrebinovo, upper portion upstream	0—20	0,44	1,50	2,71	1,50	1,56	1,59	9,30
	20—40	0,51	1,38	3,65	2,50	0,82	2,22	11,08
	40—70	0,39	1,13	3,04	1,75	1,75	1,06	9,12
	70—100	0,39	1,01	4,92	1,80	0,92	3,60	12,64
Yastrebinovo, lower portion downstream	0—20	0,48	5,19	9,48	—	—	—	30,30
	20—50	0,44	2,09	11,84	—	—	—	28,74
	50—80	0,40	1,41	10,68	—	—	—	24,98
Chervono-Mayak	0—20	0,56	13,09	2,77	1,80	2,0	12,62	32,84
	20—40	0,66	6,04	1,00	0,90	1,1	5,70	15,40
	60—80	0,92	2,20	0,50	0,20	0,50	2,92	7,24
Lower stretch								
Novoandreyev, raised portion	0—20	0,40	15,51	4,16	9,25	2,08	8,74	40,14
	70—90	0,50	5,45	2,29	2,50	1,25	4,59	16,68
Same, depressed portion	0—20	0,96	0,63	0,94	1,58	0,25	0,70	5,06
	95—105	0,59	0,39	1,25	1,25	0,17	0,81	4,46

Note: Comma represents decimal point.

a natural drain. Its action may extend a certain distance and embrace a certain area adjoining the river. Along the terrace depression, the ground waters were less saline since, being derived from the original bank, they do not have the time to become saline. The nature of the salinization of ground waters depends on drainage. Thus sulfates predominate in the ground waters along the terrace portion of the flood plain, chlorides are found in the central portion, and bicarbonates are primarily contained along the river portion.

The degree and nature of soil salinization in various portions of the flood plain vary according to the same principles. The highest degree of soil salinization is found in its central part. Here the chloride and sodium content increases sharply as compared with the remaining portions of the flood plain. The soils are desalinized and sulfates and calcium carbonates predominate along the river portion of the Yastrebinovo water-logged flood plain which is located in the upper portion of the middle stretch. Salinization is highest in the central flood plain; it embraces the entire 1-m layer. The content of chloride and sodium ions is high in the salt composition. The soils along the terrace portion of the flood plain are less salinized. The nature of the salinization is progressive, since sulfates and chlorides are contained in higher amounts in the upper layer (Table 7).

The salinization of ground waters and soils changes in a regular pattern down river. The mineralization of ground waters is relatively weak in the lower stretch. Bicarbonates predominate, then chlorides. The first place amon cations is occupied by sodium and then by calcium. The low salt content may be explained by th sample supply of river and flood waters which in undate the depressed areas of the water-logged flood plains for a long time. The mineralization of ground waters increases sharply in the middle stretches, whereby the chloride and sodium content increases greatly. Relief development does not fully ensure the discharge of ground water in to the river here, while the desalinization action of floods and waters is weaker than in the lower stretch. In the upper stretch, the ground waters are fresh and of the bicarbonate-calcium type

Table 10

Results of analysis of adsorbed cations in soil of the Southern Bug flood plain
(Ca^{++} and Mg^{++} according to I. V. Tyurin, Na^{+} according to M. M. Godlin)

Depth, cm	In meq per 100 gm of soil				In % of total cations		
	Ca^{++}	Mg^{++}	Na^{+}	Total	Ca^{++}	Mg^{++}	Na^{+}
Bug water-logged flood plains. Upper stretch. Desalinization zone.							
0—20	19,90	4,40	0,39	24,49	81,3	17,1	1.6
Chervono-Mayak water-logged flood plains. Middle stretch. Progressive salinization zone.							
0 —20	22.80	9,60	1,00	33,40	68,3	28,7	3,0

Note: Comma represents decimal point.

ause of adequate discharge (Table 8).

n the lower stretch the soils of raised relief nents are salinized primarily by chlorides ble 9). A considerable portion of the cations sists of sodium. The salts concentrate in upper horizons, a fact which points to the gressive salinization of soils in raised relief nents of the bog-solonchak zone. The soils epressed, water-logged areas are weakly nized.

n the middle stretch in the lower part of the dow-solonchak zone the chloride-sodium nization is progressive (Chervono-Mayak er-logged flood plain). Salinization decreases siderably in the upper part of the zone (upper ion of the Yastrebinovo water-logged flood n). Calcium sulfates predominate in the salt position. In this part of the flood plain, soil nization goes rather deep. The salts are nly distributed in the upper 1m, which is as- ated with the increased amplitude of ground- er level fluctuations here. Their upper level etermined by floods and their lower level by river water level during the low water period. e the processes of salinization and desalinization alternate.

n the upper stretch, where the discharge of nd waters into the river is adequate because elief development, the soils of the flood plain weakly salinized, predominantly by calcium rbonate.

hus, in the stretch of the Southern Bug flood n from the area where crystalline rocks out- to the zone of prolonged inundation in its er stretch, all stages of development of the accumulation process and its desalinization encountered: from the progressive salinization of the raised elements of the water-logged (bog-solonchak) in the lower stretch to al- ating salinization and desalinization processes and to desalinization in the upper stretch. nature of salinization also undergoes a change. Sodium chlorides, which are found in large amounts in the salt composition of soil in the bog-solonchak zone and in the lower part of the meadow-solonchak zone, are replaced by calcium sulfates, and in the upper stretch, by calcium bicarbonates.

The desalinization of the soils of the flood plain, caused by the evolution of the relief, is not accompanied by the solonetzization process. It is hindered by the fact that during the diminution of salt accumulation, sulfates predominate in the salt composition and then calcium bicarbonates.

Among the adsorbed cations in the soils of the zone of progressive salinization (Chervono-Mayak water-logged flood plain) sodium comprises 3% of the total, while in the desalinization zone (Bug water-logged flood plain) it comprises only 1.6%. The amount of adsorbed magnesium also decreases (Table 10).

All this is reason enough to divide the flood plain of the Southern Bug into four zones: 1) bog-solonchak, which is water-logged over a great part of its area and the raised relief elements of which are in a state of progressive salinization (lower stretch); 2) progressive salinization in the lower portion of the meadow-solonchak zone (lower part of the middle stretch); 3) alternating salinization and desalinization processes in the upper part of the meadow-solonchak zone (upper portion of the middle stretch); and 4) desalinization in the upper stretch, in the meadow-chernozem zone.

When classifying flood plains one must take into account that the process of salt accumulation also develops in the direction from the river toward the original bank.

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SOILS OF THE RICE FIELDS OF LOWER BURMA AND OF CERTAIN OTHER REGIONS OF THE BURMESE UNION

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The soils of the rice fields of Lower Burma[1] yield the main portion of the rice produced in Burma and on which the entire economy of the country depends. These soils so important for Burma have not been studied yet. The book of Chhibber (1), which contains the most detailed information on the soils of Burma, devotes only a few lines to the soils of the rice fields of Lower Burma: "...the rice lands are formed on alluvium, which consists primarily of fine clay loam" (page 254). There are even less data in the works of Coggin-Brown and Dey (2), and Stamp (3) than in the book of Chhibber. These authors call the soils of the rice fields of Lower Burma, alluvial.

The material on which this article is based was collected from 1958-1959 during detailed (partly field) investigations in various regions of the Burmese Union. The data on characteristics of the soils of Lower Burma rice fields were obtained primarily during work on the compilation of detailed soil maps (scale, 1:3960) for 400 ha of rice fields. The surveyed area is located 50 km from Rangoon on the road to Mandalay, and is typical for Lower Burma. The area is represented by a plain with elevations from 8-10 m above sea level, consisting of old alluvial deposits. The relief is flat, but the microrelief is rather clearly developed. There is no natural vegetation in the survey area, all is occupied by rice fields. Only villages are surrounded by small stands of coconut trees, toddy palms, mangoes, banana trees, and other tropical plants. The climate of the region is tropical, monsoon, with pronounced dry and wet periods. Precipitation amounts to 123 mm in the dry period, from November to April, with only 8 mm in January. Precipitation is 2574 mm from May to October, of which 1734 mm fall from June to August. The main temperature of the coldest month (January) is 25.4°C, and that of the warmest month (April), 30.5°C.[2] Ground water (fresh) is located at a depth of 6-7 m at the end of the dry season.

The soil of the area is heterogeneous. The soils that differ greatest from each other we call gleyey rice and degraded rice soils.

The profile of gleyey rice soils is very characteristic, it is clearly delimited into the plowed layer and the underlying part. In the dry season the plowed layer is of a light yellowish-dark bluish color with scattered rust spots and interlayers. The rest of the profile is evenly grayish-green, while in its most finely textured varieties, the subplow layer is grayish-blue. A few rust spots are found in the upper part of the profile. During the dry period the soils are riddled with cracks up to 2-3 cm wide. The entire fissured upper part of the profile (especially the subplow layer) breaks into large, very compact clods on digging. Starting at a depth of about one meter, the soil is very moist, even in the dry season, and there are no cracks.

The texture of the soil is clay, and sometimes fine clay loam. A certain textural heterogeneity along the horizons, especially the content of the physical sand fraction, is the result of the alluvial origin of these soils. Gleyey soils, as all other rice soils of Burma, are poor in humus (Table 1). The humus is rich in nitrogen (the C:N ratio is 5-8). The plowed layer has an acid reaction, while the reaction of the rest of the profile is weakly acid, or close to neutral. A considerable removal of exchangeable cations occurs from the plowed layer. It is characterized by a high content in exchangeable aluminum, which is lacking in the remaining portion of the profile. The degree of saturation by bases (according to hydrolythic acidity) is 45%-65% in the plowed layer, while in the other horizons it is always more than 75% and usually 90%-95%. The plowed layer is sometimes finer than the underlying layer and sometimes of the same texture. The results of total chemical analysis (Table 2) show that in soil, where the plowed layer does not differ texturally from the underlying layer, the distribution of sesquioxides and silicon oxide along the profile is in general, also even. Thus, in gleyey soil degradation processes embrace the plowed layer only; in many cases these processes are limited only to the acidification of the soil and the appearance in the exchange complex of noticeable amounts of adsorbed aluminum; there is no removal of the clay fraction, no losses of sesquioxides, and no accumulation of silicon

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[1] Lower part of the valley and delta of the Irravadi River and lower part of the Sittanga River valley.

[2] Precipitation data for the city of Hlegu, located 3-5 km from the survey area; temperature data for the city of Rangoon.

Table 1

Humus content, pH, physicochemical properties and texture of gleyey rice soils

Profile No.	Depth, cm	Humus, %	pH, water	Exchangeable cations		Hydrolytic acidity	Exchangeable cations		Diameter of particles, mm		
				Ca	Mg		H	Al	>0,02	0,02–0,002	<0,002
				In meq per 100 gm of soil					Content, %		
4	0–13	1,72	5,3	5,6	11,4	9,3	0,3	2,3	4,7	52,3	43,0
	20–30	0,36	7,1	6,8	17,2	0,4	None	None	25,3	32,4	42,3
	51–61	0,71	6,2	8,6	19,8	2,7	"	"	12,5	48,9	38,6
	107–117	0,68	6,8	4,2	22,2	1,3	"	"	23,5	37,6	39,7
	193–203	0,35	7,1	5,8	16,8		Not det'd.		18,8	35,5	45,7
13	0–13	1,70	4,5	6,2	9,4	9,6	0,1	2,9	7,5	49,8	42,7
	36–48	0,72	5,6	7,8	25,4	2,4	None	None	11,1	44,0	44,9
	71–84	0,81	6,2	11,2	22,6	2,2	0,1	"	7,6	43,8	48,6
	100–112	0,57	6,9	8,2	16,2	1,5	None	"	41,1	28,8	31,1
	132–145	0,92	6,3	9,8	21,4	2,0	"	"	12,9	23,2	63,9
	190–203	0,94	6,3	6,2	22,6	1,5	0,2	0,1	5,9	24,6	69,5
15	0–10	1,80	4,4	5,0	9,2	9,9	0,1	3,2	7,9	51,5	40,6
	25–38	0,92	6,6	10,4	12,6	2,8	0,2	0,1	6,2	40,5	53,3
	51–64	0,92	6,6	10,0	20,2	2,9	0,2	None	6,8	41,3	52,9
	76–84	1,05	6,1	11,0	17,8	4,2	0,1	0,1	6,4	47,8	45,8
56	0–13	1,10	4,5	3,0	2,4	7,0	0,1	2,0	42,4	29,6	28,0
	15–28	0,89	5,2	6,2	10,4	5,6	0,1	None	36,3	20,5	43,2
	38–51	0,64	6,3	6,8	16,0	1,6	None	"	30,9	22,2	46,9
	80–100	Not det'd.	6,3	8,6	19,2	4,2	"	"	10,0	28,7	61,3

Note: Comma represents decimal point.

Table 2

Total chemical composition of rice soils

Profile No.	Soil	Depth, cm	Content, % of dry soil weight		In % of the weight of ignited soil (free of water and humus)						
			Humus	Chemically bound water	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	MnO	P_2O_5
13	Gleyey rice soil	0–13	1,70	5,71	67,95	21,32	6,84	0,31	1,80	0,16	0,16
		36–48	0,72	6,96	62,65	19,72	8,30	0,35	1,78	0,09	0,12
		100–112	0,57	5,09	68,77	20,24	6,47	0,49	1,69	0,15	0,12
		190–203	0,94	7,68	62,30	24,90	8,13	0,36	1,76	0,10	0,10
34	Degraded rice soil	0–13	1,00	2,97	86,05	7,40	2,07	0,15	0,21	0,09	0,02
		25–38	0,43	2,54	84,65	8,15	1,12	0,22	0,21	0,07	0,03
		58–68	0,28	5,43	86,35	7,94	1,12	0,11	0,13	0,06	0,02
		140–153	Not det'd	4,81[a]	74,00	18,80	5,36	0,30	0,37	0,13	0,03

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[a] Ignition loss

Note: Comma represents decimal point.

le in the plowed layer.

The gleyey soils contain a small amount of ly soluble salts, primarily sodium salts (not more than 0.1%-0.2%) and lack carbonates. The high content of exchangeable magnesium is conspicuous, which is apparently due to the composition of rocks in the area, which formed as a result of the filling in of a bay by fluvial deposits.

In spite of their fine texture and intense gleyization, gleyey soils have a rather low bulk density (1.2-1.4 in the upper layer and 1.4-1.5 in the rest of the profile) and a rather high porosity (45%-57% and 40%-50%, respectively).[3] The soils shrink and swell considerably. Gleyey soils are very hard during the dry period. Determinations with the Kachinskiy penetrometer with a cylindrical shaft gave 70-120 kg/cm² for the plowed layer (with a moisture content of 1%-5%) and 90-120 kg/cm² for the underlying layer (with a moisture content of 10%-15%). At the end of the dry season the upper 0.5 m of the soil retains 70-120 mm of moisture (or 30%-50% of the field moisture capacity) and the 1 m layer, 200-300 mm (40%-70% of the field moisture capacity). The moisture available to plants, considering the very fine texture of the soils, is found only from a depth of about one meter during the dry period, where the moisture content reaches 80%-95% of the field moisture capacity.

Gleyey soils are only slightly permeable. The permeability of the clayey varieties after the flooding of cracks amounts to about 1 mm/day.[4]

Degraded rice soils differ greatly from gleyey soils by the nature of their surface, which has a whitish color and is not cracked. Indistinct rust spots are scattered against the whitish background of the profile of this soil; their number and sharpness increase with depth. Iron concretions begin to appear from a 50-100 cm.

The texture of the soil is usually fine and medium clay loam. The upper part of the profile is coarser than the lower. Degraded soils differ sharply from gleyey soils by their chemical properties (Table 3). Their entire profile (down to a depth of 100-150 cm) has a weakly acid reaction and is poor in exchangeable bases. The aluminum content is considerable in all horizons (except that underlying the plowed layer) and increases somewhat with depth. The degree of base saturation is 45%-55% and is 60%-70% only in the subplow horizon. A removal of the clay fraction occurs in the upper part of the profile (50-80 cm thick). These horizons are very poor in sesquioxides and rich in silicon oxide. Thus, degradation processes embrace the entire upper part of the profile of degraded soils and are much more strongly expressed than in gleyey soils. It is interesting that the lower part of the profile of the foregoing soils, which is illuvial judging from the result of particle-size and total chemical analyses, is poor in exchangeable bases and rich in exchangeable aluminum. Thus, the illuvial horizon also shows the first signs of degradation.

Degraded rice soils are non-carbonated and contain less than 0.1% of easily soluble salts.

The bulk density of the upper layer of the foregoing soils is 1.2-1.5 g/cm³ and that of t rest of the soil 1.5-1.7 g/cm³. Porosity is 4 55% and 48%, respectively. The shrinkage a swelling of the soils are insignificant. The soils are very hard at the end of the dry seas being 70-120 kg/cm² in the plowed layer at a moisture content of 1%-3% and sometimes up 140 kg/cm² in the lower horizons at a moistu content of up to 15%. At the end of the dry s son the upper 0.5 m of soil retains 30-60 mm of moisture, or 15%-30% of the field moistur capacity, and the upper 1 m retains 100-150 mm, or 25%-45% of the field moisture capaci During this period moisture available to plai is apparently found only at a depth of more than 1.5 m, where soil moisture is 20%-25%. The permeability of degraded soils is 2-3 mn and becomes approximately constant a few ho after the begnning of experiments, while this requires several days in gleyey soils.

Part of the degraded soils of the area described has been lately used for grass and no rice. These soils are characterized by a higher humus content in the upper horizon (ab 2%) and a higher content of available forms o nutrients, especially phosphorus. The color their upper horizon is not whitish, but grayis A higher content of humus and nutrients is als found in the upper horizons of degraded soils under the tree stand surrounding the villages.

Let us dwell briefly on other soils in the area described. Rice soils intermediate between gleyey and degraded soils have been su divided by us into: 1) gleyey soils which are degraded in the lower horizons; and 2) gleye only slightly degraded soils.

Gleyey soils which are degraded in the low horizons to a depth of 40-60 cm resemble gley soils of a finer texture. Below a depth of 40-60 cm there is a whitish, degraded horizon. The texture of the soil varies from medium clay loam to fine clay loam, whereby the plowed and degraded layers are finer in texture than the gleyey horizon between them. Th chemical properties of the gleyey horizon of the foregoing soils are similar to those of gleyey soils, while the degraded horizon is similar in its properties to degraded soils. The foregoing soils are sometimes closer to gleyey soils (Profile 25, Table 4) and sometin closer to degraded soils (Profile 28, Table 4) depending on the thickness of the gleyey horizo and the degree of degradation. Many physical properties also point to the intermediary natur of these soils. They shrink and swell less than gleyey soils, but more than degraded soils. During the dry period these soils are usually riddled with small cracks and only their finer textured varieties lack cracks. Pe meability varies from 0.3 mm/hr in the finer textured and less degraded varieties to 2 mm/hr in the most coarser textured and degraded varieties, i. e., it also is of an intermediary nature.

Gleyey, only slightly degraded soils are clearly divided into two horizons. The upper part of the profile (to a depth of 48-80 cm) is texturally finer and noticeably poorer in exchangeable bases than the lower part. Gleyization processes are more pronounced than in

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[3] Data are available for 13 profiles.

[4] Determinations were made at six spots.

Table 3

Humus content, pH, physico-chemical properties, and particle-size analysis of degraded rice soils

Profile No.	Depth, cm	Humus, %	pH, water	Exchangeable cations		Hydrolytic acidity	Exchangeable acidity		Particle diameters, mm		
				Ca	Mg		H	Al	>0,02	0,02—0,002	<0,002
				In meq per 100 gm of soil					Content, %		
34	0—13	1,00	5,2	3,8	3,0	5,8	Нет	1,9	36,8	38,3	24,9
	13—23	0,47	5,6	3,2	4,8	3,8	0,6	0,3	44,6	32,5	22,9
	25—38	0,43	5,6	3,4	3,0	6,9	0,1	1,8	34,1	38,6	27.3
	58—68	0,28	5,6	3,6	3,6	6,6	0,1	2,7	35,7	35,6	28.7
	95—105	Not det'd.	5,5	3,4	6,4	9,6	0,1	4,9	29,4	29,7	40,9
	140—153	"	5,1	Not det'd.		11,3	0,1	5,6	26,5	22,1	51,4
46	0—5	1,15	5,1	3,2	2,6	5,2	0,1	1,2	44,1	35,7	20,2
	15—23	0,67	5,5	2,0	2,2	2,6	0,5	0,3	53,2	23,2	23,6
	51—58	0,47	5,3	2,6	3,6	6,4	0,2	2,0	36,0	17,5	46,5
	100—105	0,30	5,4	2,4	2,8	6,5	0,4	1,8	38,5	14,6	46,9

Note: Comma represents decimal point.

graded soils. These soils are closer to
graded soils in their physical properties.

Weakly gleyed sandy loams or fine clay loams
ere also found in the area surveyed on fine-
xtured deposits. These soils have the highest
ter permeability among the rice soils de-
ribed.

Aggregate analyses were made of the plowed
d subplow layers for 16 profiles. These hori-
ns in all soils break into large clods when dry.
der wet sieving[5] the clods of the subplow
rizon disperse more rapidly than those of the
owed layer. The clods of the plowed layer
sintegrating in water belong almost entirely
the <0.25 mm diameter fraction in gleyey
ils and for the greatest part in the other
ils. From 30%-70% of the soil material in
ods from the subplow layers is held back by
eves with 1-3 mm openings when disintegrat-
(the rest belongs primarily to the <0.25 mm
meter fraction). Thus, if the structure of
plowed layers of rice soils is practically
ly destroyed, the same is not true of the
plow layers. It is possible that the compara-
ely high porosity of the subplow horizons,
ich are strongly gleyed in many rice soils,
associated with their "hidden" aggregation.

The rice soils of the area described vary
eatly in their productivity. The highest
lds (16-18 cntr/ha) are obtained on gleyey,
e clay loams and coarse clay loams. Some-
at lower yields are obtained on gleyey, medi-
and fine clay loams, and also on various
ermediate soils. The lowest yields (11-13
r/ha) are obtained on degraded soils.

Detailed soil investigations and levelling of the area showed that the soil of the surveyed area is of a complex nature and is associated with the microrelief. The microrelief of the area includes the following elements: 1) rounded sinkholes covering several hectares; 2) elongated depressions in the form of weakly developed troughs; 3) elevations between the sinkholes; 4) wide, flat elevated areas; and 5) wide, flat depressed areas. The level of the bottom of the sinkholes and troughs is 40-100 cm lower than the level of the surrounding elevations. The difference between the height of flat elevations and that of the surrounding depressions is approximately the same. Large sinkholes and troughs are occupied by gleyey soils (Fig. 1), whereby the soils are finer in the central parts of the sinkholes. The elevations surrounding the sinkholes are occupied by gleyey, only slightly degraded soils. Gleyey soils which are degraded in their lower horizons occupy flat depressed areas, small sinkholes, and often the edges of large sinkholes. Flat elevated areas are occupied by degraded soils. Only weakly gleyed soils do not show a clear relation with the relief, they are found on coarse-textured materials and fully depend in their distribution on the location of these materials. A developed microrelief is also found in many individual rice fields (check plots), even though the difference in elevations here is only a few centimeters. Soils within a single check plot differ usually only by their texture — the micro-sinkholes are occupied by finer soils.

The foregoing soils are characteristic of the greatest part of Lower Burma, even though the diversity of rice soils in this area is not limited to the above soils alone. Various types of gleyey soils and soils intermediate between gleyey and degraded soils are widely distributed over Lower Burma. Degraded soils are generally found in the marginal areas of Lower Burma, bordering on the neighboring mountain areas.

Investigations in the rice-field area of the

About 1 kg of soil was placed on sieves and im-
rsed in water for 2 minutes and the sieves were
wly immersed and removed from the water 10
es.

Table 4

Humus content, pH, physicochemical properties, and particle-size analysis of rice soils

Profile No.	Soil	Depth, cm	Humus, %	pH, water	Exchangeable cations		Hydrolytic acidity	Exchangeable acidity		Particle diameters, mm		
					Ca	Mg		H	Al	>0,02	0,02—0,002	<0,002
					meq per 100 gm of soil					Content, %		
25	Gleyey, degraded in the lower horizons	0—13	1,14	4,4	2,2	3,4	6,8	0,1	2,3	37,0	35,7	27,3
		15—25	1,03	5,4	6,8	14,7	2,5	0,1	None	26,4	29,0	44,6
		36—46	0,93	5,4	16,8	10,4	3,2	0,2	0,1	22,8	30,2	47
		72—88	Not det'd.	5,4	3,4	10,6	1,3	0,1	None	53,7	23,0	23,3
		102—115		5,4	1,8	6,6	3,2	None	0,6	35,3	21,2	43,5
28	Gleyey degraded in the lower horizons	0—10	1,62	5,0	2,8	6,4	9,8	0,1	4,6	—	—	—
		15—25	1,09	6,2	8,0	15,2	5,0	0,1	0,4	—	—	—
		46—61	0,49	5,7	0,8	4,6	4,2	0,2	1,7	—	—	—
		80—95	0,39	5,8	3,4	2,4	8,5	0,1	4,0	—	—	—
10	Gleyey, only slightly degraded	0—10	0,94	5,1	2,6	2,6	5,1	0,3	1,3	58,8	24,9	16,3
		18—30	0,39	5,3	4,4	6,2	2,5	0,2	0,1	68,7	8,2	23,1
		38—53	0,28	5,3	2,8	6,4	2,0	0,1	0,1	75,6	5,3	19,1
		61—76	Not det'd.	5,3	4,6	9,0	2,5	0,1	0,2	66,3	14,7	19,0
		84—102	"	5,2	8,4	17,8	3,7	0,2	0,2	13,5	39,8	46,7
		124—136	"	5,4	8,4	16,2	3,6	0,4	0,1	31,1	49,4	49,5
		152—162	"	Not det'd.	5,8	12,3	2,4	0,2	0,1	70,9	6,8	22,3
19	Gleyey, only slightly degraded	0—13	1,08	5,2	2,8	1,8	7,2	0,1	2,7	—	—	—
		15—25	1,11	5,6	7,8	8,6	4,5	0,1	0,7	—	—	—
		36—46	0,63	5,7	8,0	10,4	3,6	None	0,2	—	—	—
		66—79	0,58	5,6	10,4	11,8	3,5	0,3	0,1	—	—	—
		102—112	0,46	6,1	5,8	6,2	4,2	0,1	0,1	—	—	—
		125—140	0,46	5,6	6,8	8,4	2,7	0,1	0,1	—	—	—
70	Weakly gleyed	0—10	1,16	5,3	4,8	4,6	5,4	0,4	0,9	61,8	13,5	24,7
		20—30	0,81	5,5	6,8	7,2	4,0	0,2	0,4	67,2	13,8	19,0
		48—58	0,37	6,2	6,2	4,0	2,6	0,2	0,1	73,6	5,4	21,0
		90—102	0,40	6,2	7,2	6,2	2,3	0,3	None	Not det'd.		

Note: Comma represents decimal point.

Tenasserim shore (14°N lat) showed that soils are found there which are very close to the gleyey and degraded soils of Lower Burma. The gleyey rice soils of the area investigated[6] differ from the soils of the same name in Lower Burma by their thicker and whitish plowed horizon, their less cloddiness, and their higher water permeability. Degraded rice soils were found in Tenasserim at the edges of rice lands in the vicinity of forests. Degraded soils there have a whitish color with yellowish and reddish-brown spots, similar in color to the neighboring forest soils.

In Upper Burma (in the area bordering on the middle stretch of the Irravadi River) rice is mostly grown under irrigation (usually insufficient) from small artificial reservoirs, because of deficient precipitation,[7] while in Lower Burma the moisture derived from rain is more than sufficient. In Upper Burma rice is grown on dark compact, cinnamon-brown, and even reddish-brown meadow soils. Rice cultivation left a definite impression on these soils, especially on red-brown and cinnamon-brown soils, however they are far from being specific as the rice soils of Lower Burma are. With all their diversity, the rice soils of Upper Burma have a number of characteristics distinguishing them from the rice soils of Lower Burma: 1) the processes of gleyization and degradation are weakly developed, or almost absent in the rice soils of Upper Burma; 2) their reaction varies between neutral and alkaline; 3) as a rule, there are carbonates in the soil profile; and 4) exchangeable calcium

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[6] The mean annual amount of precipitation here is 5500 mm, 200 mm of which falls during the dry period.

[7] The mean annual amount of precipitation here is 500–800 mm with dry air and high evaporation.

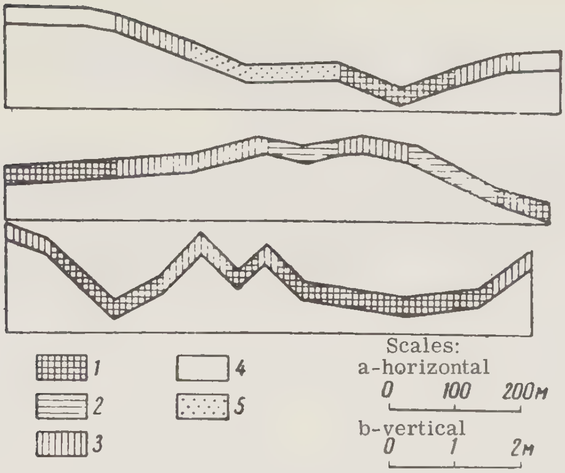

Fig. 1. - Distribution of soils in rice fields depending on microrelief.

1 - gleyey soils; 2 - gleyey soils, degraded in the lower horizons; 3 - only slightly degraded gleyey soils; 4 - degraded soils; 5 - weakly gleyed.

lly sharply predominates over exchange- magnesium. We will not describe here mber of other differences inherent to one or other group of soils in Upper Burma and h are not common for all these groups.

he rice soils of Upper Burma yield less those of Lower Burma. This is apparent- ie to the lesser moisture supply in Upper ma and generally less favorable physical properties for rice. As far as nutrients concerned almost all rice soils of Burma deficient in nitrogen and phosphorus.

Conclusions

. Detailed soil investigations in a typical field area of Lower Burma showed that oil of rice fields is heterogeneous. Gleyey degraded soils, as well as various soils mediate between these two groups, pre- nate. Gleyey soils, as well as the inter- ate varieties, are widely distributed over r Burma. Degraded soils are found most- marginal, slightly elevated areas.

Among the soils studied in Lower Burma y soils of fine clay loams and coarse clay s give the highest rice yields, while de- ed soils give the lowest.

The diversity of soil in the rice field area termined by microrelief. The lowermost areas are occupied by gleyey soils and the highest, by degraded soils. Intermediate varieties generally occupy the intermediate positons in the relief.

4. The rice soils of the Tenasserim shore are close to the rice soils of the Lower Burma.

5. The rice soils of Upper Burma, in spite of their diversity, have certain common characteristics which distinguish them from the rice soils of Lower Burma.

6. Yields in the rice fields of Upper Burma are generally lower than in the rice fields of Lower Burma, which is probably due to the lower soil moisture supply in Upper Burma and the generally unfavorable physical soil properties for rice.

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DEEPENING OF THE PLOWING LAYER AND RADICAL ALTERATION OF THE PROFILE IN PODZOLIC AND SOD-PODZOLIC SOILS OF DIFFERENT TEXTURE

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One fundamental approach to the cultivation of podzolic soils is to increase the thickness of the plowing layer. That this increases the fertility of podzolic and sod-podzolic soils is shown by the fact that where these soils are found the thickness of the plowing layer often does not exceed 16-18 cm, which is inadequate for high yields, even when fertilizer, liming and other measures are employed.

We note that if the thickness of podzolic and sod-podzolic soils is increased by 5-10 cm this often results in negative developments that are difficult to correct. It has therefore long been the practice to recommend that the depth of plowing should not be increased by more than 2-3 cm at a time and that organic and mineral fertilizers and liming should be employed concurrently. Even the gradual extension of plowing depth on these soils may however yield only a slight result or a negative one if allowance is not made for the degree of podzolization, the structure of the profile, texture and other features. This must be explained by describing the features of these soils.

Podzolic and sod-podzolic soils are divided into a considerable number of types by the structural features of the profile, by texture and the degree of podzolization and by other features and properties. The soil stratum is normally differentiated into a series of genetic horizons of different texture, chemical composition and properties, in relation to the intensity of podzolization in the past and to the mineralogical and particle-size composition of the parent materials.

Podzolic and sod-podzolic soils are classified as weakly-moderately- and strongly-podzolic and podzols are also classified by the thickness, development and formation of the podzolized and humic horizons (Fig. 1).

These soils are divided by texture into sandy, sandy laom, clay and clay loam. The well-developed podzolic layer is mainly composed of small fragments of sterile quartz.

An increase in the quantity of quartz particles in the plowed layer from the podzolized layer normally decreases the already low capacity for aggregation and the acquisition of a structure of value to agriculture. The podzolized layer is acid and has a low nutrient level.

The distinction between the composition and properties of the podzolized and humic horizon is greatest with cohesive strongly- and moderately-podzolic soils and is less clearly defined in sandy and sandy loam soils. When, therefore, we increase the thickness of the plowed layer at the expense of the podzolized layer and thus extend the reservoir for water, air and nutrients, we worsen the soil by introducing sterile quartz into the plowed layer. Use of the methods recommended for the cultivation of cohesive moderately- and especially strongly-podzolic soils is often not sufficient entirely to remove the negative features thus introduced. The only explanation for this is that increasing the thickness of the plowed laye at the expense of the podzolized layer does not remove the latter's negative features. The mo important aspect of the process is that the addi tion of silicic acid to the plowed layer from even part of the podzolized layer causes an irreversible deterioration in its already poor physical properties, since both layers, and especially the latter, are poor in the secondary clay minerals of aluminosilicate clay.

It may be thought, therefore, that another approach is necessary for soils in which a podzolized horizon with negative features is already developed and that no attempt should b made to increase the thickness of the plowing layer by plowing the podzolized layer into it. Instead one should use methods to remove the podzolized layer within the soil and substitute even a part of the illuvial horizon, which is richer in clay particles containing phosphorus, potassium and other elements.

Bushinskiy's experiment (2) is one such attempt to alter radically the profile of a sod-podzolic soil. This experiment was not successful since deep plowing turning to a depth of 60-70 cm was used to remove the podzolized layer and no account was taken of the profile structure, degree of podzolization and texture of the soil. This approach could only be positive on podzols with a 2-3 cm humus layer and a very thick (up to 30-40 cm) podzolized horizon. In this case, i. e., when the soil is plowed to a depth of 70 cm, an illuvial layer from which a cultivated plowing layer can be created without the participation of the podzoliz

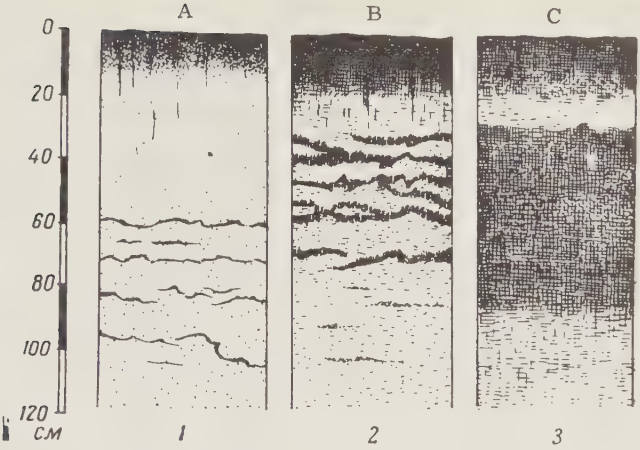

Fig. 1. - Structural outline of the profile of sod-podzolic soils.

A - sod-weakly-podzolic soil; B and C - sod-medium-podzolic soils. 1 - sandy; 2 - sandy loam; 3 - loam.

er and without the humus that is almost
ent from this soil is raised to the surface.

When this method is used on podzolized soils
h a 18-20 cm humic plowing layer, we irre-
sibly bury 50-100 metric tons/ha of organic
tter to a depth of 60-70 cm. It would take
re than 10 years to grow the 1000-2000 met-
tons of plant mass necessary to replace
s organic matter.

In our opinion one must replace the podzol-
d horizon by the upper part of the illuvial
izon while retaining the humus plowing
er at the surface and thus create a com-
ely new podzolic soil profile. We began
erimental study of this type of alteration of
-podzolic soil profiles in 1947. We were
led by the following considerations in plan-
g the experiments: 1) the possibility of im-
ving the water-physical properties of the
and removing the layer (podzolized) that
lers the development of the plant root
tem by burying the infertile podzolized
r deep in the soil and replacing it by the
er part of the illuvial horizon; 2) that the
sical properties of the plowed layer would
radually improved by subsequent deep plow-
and the incorporation of illuvium in the plow-
layer, especially when additional cultivation
niques were employed. We were also of
opinion that the efficacy of the measure
ld be directly proportional to the level of
zolization and to the extent to which the
vium contained clay elements.

'o test the methods indicated we set up long-
n field experiments, the results of which are
n in Tables 1-5,[1] in the autumn of 1947.
se experiments were on sod-weakly- and
erately-podzolic sandy loams in 3 kolkhozes
ie Makarov district of the Kiev region and at Goloseyevo (near Kiev). Results of aggregation-dispersion particle size and chemical analyses of the soils on the experimental plots are given in Table 1.

The results in Table 1 show that the illuvial horizons compare favorably with the podzolized and even the plowed (humus-eluvial) horizons in their content of particle diameters <0.001 mm and in the minimum of stable aggregates >0.01 mm in diameter.

The data in Table 2 show that the illuvial horizon (I) contains more adsorbed bases than the podzolized (E) and humus-eluvial (HE) horizons. Total acidity of the illuvial horizon is less than that of the upper horizons.

Not being in possession of a special multilayer plow and wishing in as far as possible to avoid mixing the podzolized horizon and the plowed layer, we cultivated the soil by first raising three layers of soil (0-20, 20-35 and 35-50 cm) with three shovels. The 20-35 cm (podzolized) layer was thrown to the bottom of the furrow, the 35-50 cm layer was turned on top of the podzolized and the humus (plowed) layer was turned and returned to its former position. The podzolized layer was thus buried deep in the soil.

The 1947-1948 experiment was conducted in sod-weakly podzolic sandy loam (Goloseyevo) on 25 m^2 plots (replicated 3 times), the crop was winter rye and the fertilizer $N_{45}P_{45}K_{30}$ manure applied at a rate of 30 metric tons/ha.

The experimental results (Table 3) showed that for a soil with a slightly developed podzolized layer, deep cultivation with or without removal of the podzolized layer gave the same results as on the control plot and when manure was applied. Removal of the podzolized layer only had an appreciable effect when organo-mineral mixtures were applied.

The results of a potato experiment on the

.A. Kuks helped with the 1947-1958 experiments.

Table 1

Results of aggregation-dispersion and particle-size analyses of experimental plot soils, %

Analysis	Depth, cm	Diameter of particles and aggregates, mm >0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	<0,001	Subs solu in 0.0 N HCl
Weakly-podzolized sandy loam, Goloseyevo								
Aggregation-dispersion	0—20	13,87	80,66		4,86		0,70	—
Particle size	»	13,70	15,80	50,07	4,60	4,30	10,60	1,0
Minimum of stable aggregate	»	0,17	14,79		—		—	—
Aggregation-dispersion	20—35	15,45	81,51		2,00		1,04	—
Particle size	»	13,80	16,01	61,89	1,44	1,11	5,20	0,5
Minimum of stable aggregate	»	1,65	3,61		—		—	—
Aggregation-dispersion	35—50	13,32	79,56		5,14		1,98	
Particle size	»	10,84	16,50	47,14	5,87	5,92	12,78	0,9
Minimum of stable aggregate	»	2,48	15,92		—		—	
Transitional from weakly- to moderately-podzolic sandy loam, Mostishche								
Aggregation-dispersion	0—20	18,88	72,83		7,29		0,46	
Particle size	»	17,60	26,70	39,29	10,68		5,72	
Minimum of stable aggregate	»	1,28	6,84		—		—	
Aggregation-dispersion	20—35	17,87	73,82		7,74		0,57	
Particle size	»	17,14	28,36	37,82	11,88		4,80	
Minimum of stable aggregate	»	0,73	7,64		—		—	
Aggregation-dispersion	40—50	17,35	71,66		9,02		1,97	
Particle size	»	16,73	24,63	30,98	9,66		17,68	
Minimum of stable aggregate	»	0,62	16,04		—		—	
Moderately-podzolic sandy loam, Pashkova								
Aggregation-dispersion	0—20	27,63	66,65		5,18		0,27	
Particle size	»	26,89	21,27	36,82	9,78		5,24	
Minimum of stable aggregation	»	0,74	8,06		—		—	
Aggregation-dispersion	25—35	26,72	67,03		5,69		0,56	
Particle size	»	25,15	24,56	36,88	9,30		4,11	
Minimum of stable aggregate	»	1,57	5,59		—		—	
Aggregation-dispersion	40—50	20,87	70,05		7,79		1,29	
Particle size	»	20,19	25,77	29,75	8,18		16,11	
Minimum of stable aggregate	»	0,68	14,53		—		—	
Moderately-podzolic sandy loam, Lyshnya								
Particle diameter composition	0—18	28,69	21,00	32,96	5,96	4,23	7,76	1,7
	20—30	28,01	20,99	33,74	5,72	5,11	5,70	0,7
	35—45	21,22	18,80	27,96	5,54	6,61	19,16	1,3

Note: Comma represents decimal point.

same plots re-dug to an identical depth of 25 cm are given in Table 4.

Table 4 shows that positive results were obtained on all the plots in the experiment even on sod-weakly-podzolized soil in the secon year after removing the podzolized layer t deeper horizon and substituting the illuvia layer, 5 cm of which were mixed in with t plowed layer on re-digging, to 25 cm. Th

Table 2

Results of physicochemical analysis of experimental plot soils

Soil and location	Genetic horizon	Depth, cm	Humus, %	S, meq	Total acidity	pH salt
eakly-podzolic sandy loam, loseyevo	HE	0—20	2,07	8,3	1,80	6,4
	E	20—35	0,31	3,1	2,01	5,8
	I	35—50	0,53	10,7	—	6,1
ansitional from weakly- to moder-tely-podzolic sandy loam, ostishche	HE	0—18	1,34	3,7	1,65	5,6
	E	22—32	0,57	2,3	1,53	5,8
	I	44—54	0,30	6,9	1,3	6,0
oderately-podzolic sandy loam, Pashkovo	HE	0—19	1,32	3,32	2,09	5,6
	E	23—33	0,40	2,60	1,55	5,6
	I	45—55	0,32	6,55	1,18	5,8
oderately-podzolic sandy loam, yshnya	HE	0—18	2,04	5,98	2,65	6,2
	E	20—30	0,44	2,11	3,08	6,2
	I	35—45	0,67	8,84	2,02	6,0

e: Comma represents decimal point.

Table 3

Results of 1947-1948 experiments

Depth of soil tillage, cm	Control				Manure				1/2 NPK + 1/2 humus			
	Grain		Straw		Grain		Straw		Grain		Straw	
	cntr/ha	%	cntr/ha	%	cntr/ha	%	cntr/ha	%	cntr/ha	%	cntr/ha	%
0—20 tilled and turned	26	100	48	100	28	100	52	100	27	100	53	100
0—30 same	28	108	55	114	32	114	63	121	30	111	61	115
0—50 -20 and 20-50 ayers turned	28	108	61	127	32	114	65	125	36	133	74	140

Table 4

Results of 1949 experiment

Depth of soil tillage, cm (preceeding)	Potato harvest					
	Without fertilizer		$N_{45}P_{60}K_{60}$		$^1/_2$ NPK+ +$^1/_2$ humus	
	cntr/ha	%	cntr/ha	%	cntr/ha	%
0—20 (tilled and turned)	135	100	197	100	233	100
0—30 (Same)	171	127	215	109	242	104
0—50 0-20 and 20-50 layers turned	200	141	257	130	288	124

Table 5

Results of 1952 experiment

Depth of soil tillage, cm (preceeding)	Flax harvest			
	Grain		Straw	
	cntr/ ha	%	cntr/ ha	%
0—20 (tilled and turned)	5,6	100	14,9	100
0—30 (same)	4,9	88	15,0	100
0—50 (0-20 and 20-50 layers turned)	6,4	114	18,7	126

Note: Comma represents decimal point.

can be explained by improvement in the water and physical properties of the plowed layer by the addition of the clay material of the illuvial horizon.

In a 1952 field experiment on the same soil, flax was sown on a two-year sod of perennial grasses. The soil had been cultivated in the same way as for the rye experiment of 1947-48, with the application of $N_{25}P_{45}K_{45}$. The sod beneath the flax was excavated to a depth of 25 cm. The experimental results are given in Table 5.

Table 5 shows that removal of the podzolized layer, substitution of an illuvial layer and the mixing of part of the illuvium (5 cm) with the plowed layer had a considerable effect on the flax yield in the fourth year after radical alteration of the sod-weakly-podzolized soil profile.

Similar experiments were conducted in 1950-52 by Merzlyakov (3), and Mosolov (4, 5). These experiments showed that radical alteration of of the profile of podzolic and sod-podzolic soils, in which part of the illuvium was substituted by a multi-layer plow for the podzolized layer, had an evident beneficial effect – the yield of all crops (wheat, rye, oats, potatoes, sugar beet) was noticeably increased in the first and second years after the treatment.

In order to convince ourselves that the effect of the treatment really was most marked when the level of podzolization was sharpest, we conducted experiments in 1957-1958 at three points in the Makarov district of the Kiev region. In the villages of Pashkova and Lishnya the experiments were on sod-moderately podzolic soil, and in Mostishche on sod-weakly podzolic soil (in the process of transition to moderately-podzolized). The experimental results are given in Table 6.

The data in Table 6 show that the treatment was positive and that the effect of radical alteration of the profile is directly proportional to the degree of podzolization of the soil (flax yield in Pashkova).

In the Lishnya experiment, 5 cm deepening on a sod-moderately-podzolic coarse clay loam and the addition of a thin stratum of the podzolized layer had an effect that was positive although slight. Increase in the thickness of the plowed layer by 10 cm from the podzolized layer led to a clearly negative effect on the sod-moderately and even on the weakly-podzolic soils of the Makarov district.

Thus, one can conclude both from theoretical considerations and from experimental results that the approach to the creation of a thick plowed layer on podzolic and sod-podzolic soils must be varied in relation to the degree of podzolization and the other features of these soils (profile structure, texture).

The variation in approach recommended by us is shown in Table 7. In all sod-weakly-podzolic soils one needs to increase the thickness of the plowed layer by deepening plowing independent of their texture, since there are no significant differences in these soils between the humus-plowed layers and the podzolized layers and layers beneath the plowing (apart from the presence of humus in the plowed layer).

In moderately-podzolic soils, where the podzolized horizon is markedly developed and equal in thickness to the plowed layer, one must vary the approach. On coarse-textured soils (sandy and sandy loam) sod-moderately-podzolic and podzolic soils, in which illuvium is only present as ortsand belts and strips we recommend that the plowing should merely be deepened, whereas on cohesive (clay and clay loam) soils at the same level of podzolization in which there is continuous illuvium at a slight depth (not below 35-40 cm) multi-layer plowing, by which the podzolized layer is plowed in deeper, should be used.

On coarse-textured strongly-podzolic soils the plowing should be gradually deepened, since these soils do not have a continuous clay

Table 6

Results of 1957 experiments. Fertilizer $N_{45}P_{45}K_{20}$

Plot No.	Depth of soil tillage, cm	Pashkovka				Mostishche			
		Flax				Millet			
		Grain		Straw		Grain		Straw	
		cntr/ ha	%	cntr/ ha	%	cntr/ ha	%	cntr/ ha	%
1	0—20 (tilled and turned)	2,39	100	20,60	100	11,2	100	30,9	100
2	0—30 (Same)	2,30	96	19,80	96	9,0	80	25.4	82
3	0—50 (0-20 and 20-50 layers tilled and turned)	4,68	196	27,2	132	14,0	125	45,0	147

te: Comma represents decimal point.

Table 7

Plan of measures to create a thick plowing layer of sod-podzolic soils

Degree of soil podzolization	Soils with illuvium as pseudofibers or ortsand strips		Soils with continuous illuvial layer	
	Sandy	Friable sandy loams	Clay loams and cohesive sandy loams	Clays
akly-podzolized	Deepening of the plowed layer			
erately-podzolized	Deepening the plowed layer		Shifting the podzolized layer deeper	
ngly-podzolized	Deepening the plowed layer		Shifting the podzolized layer deeper	
zols			Raising illuvial layer to the surface	

ium. On strongly-podzolic cohesive soils,
e other hand, one should only use multi-
r plowing and plow the podzolized layer
er, which is replaced by illuvium immedi-
below the plowed layer. When the thick-
of the plowed layer is subsequently ex-
ed, it will be added to by the clay illuvium
not by the infertile podzol.

podzols are already plowed or earmarked
lowing, very deep plowing in which the
ium is brought to the surface should be used
he cultivated plowed layer should be created
e clay illuvium and not on the infertile pod-

ny measure of rationalization must be as-
ed for economic effect. In our opinion the
omic effect of multi-layer plowing on
rately- and strongly-podzolic soils cannot
sputed, since it need only be done once in
at many years. The problem is only one
mass production of multi-layer plows,
esign for which is already available (1).
these plows, kolkhozes can gradually
t a radical improvement in their fields
ut disturbing the crop rotation (podzolized, sod-podzolic and light grey podzolic soils).

Conclusions

1. The approach to the creation of a deep plowing layer in podzolic and sod-podzolic soils must be varied.

2. When there are developed podzolized and illuvial horizons in the soil with a sharply distinct profile we recommend that the podzolized layer should be plowed deeper in the soil and replaced by the upper part of the illuvium, the clay particles of which will subsequently enrich the plowed layer.

3. The plowed layer of soils in which the podzolized horizon varies little in composition and properties from the humus and illuvial horizons (all weakly-podzolized, all sandy and sandy loam soils) must be gradually increased by plowing in conjunction with other cultivation methods.

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OIL EROSION IN THE FOREST-STEPPE DISTRICTS F THE ANGARA

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Erosion processes, i.e., destruction of the l by surface waters and wind, are wide- ead in several districts of the Irkutsk region. vever, little is known about the foci of ero- n and about its nature and causes.

The first information about abandoned eroded ls and the easy erodibility of certain soils published separately by Kozlov (7), Preyn , and Krishtovich (9). The appearance of sion in the subdistrict (kray) was later indi- ed by Chernykh (20), Dubov (4), Nikolayev , Voskresenskiy (2), Makeyev (10), and lezhdin (11).

In 1956-1957 we studied the soil and soil sion in certain forest-steppe districts of the gara under the direction of Nadezhdin: the hanskiy, Osinskiy and Nukutskiy districts. paper contains a general description of the ead of accelerated surface (sheet) erosion cesses in this territory and a working classi- tion of the eroded soils.

In Shotskiy's outline of natural districts (22) territory belongs to the subdistrict of the utsko-Balaganskiy steppe of the Irkutsk- aganskiy forest-steppe district (except for north of the Osinskiy district). It is a e land, deeply dissected by the hydrographic on the southern edge of the Central Siber- Tableland.

The density of the hydrographic net varies ween 0.6 and 0.8 km/km². The depth of l erosion levels varies between 100 and m on the right bank of the Angara and from to 200 m on the left bank.

Eastern Siberia has a sharply continental cli- e. The insignificant precipitation (250-400 annually) is unevenly distributed by years especially by seasons. The bulk (approx.) falls in July and August. This precipita- peak accelerates soil erosion, especially lack fallows and on fields carrying row ps, since other agricultural land is to some nt protected at this period in the summer lants.

There are very specific soil features to erritory. Sod-carbonate cinnamon-brown s are formed on the carbonate-rich red hering products of upper Cambrian sedimen- rocks under forest vegetation. These soils are found in places in steppe areas which, in all probability, were forest in the recent past. Nadezhdin (11) divides these soils into forest and steppe (arable) soils. The first category includes sod-carbonate cinnamon-brown typical, leached and podzolized soils, and the second — sod-carbonate cinnamon-brown arable deep- and high-effervescing soils.

The shallow solonetzic chernozems which cover a large part of the area are also divided into deep- and high-effervescing soils. Shallow chernozems are normally laid down on the steppe aggradation and structural river terraces and on the slopes of low hills, mainly on loess-like drift deposits.

With the exception of the north of Osinskiy district, forests cover 30% of the forest-steppe area, and their size continues to diminish. In the majority of cases accelerated erosion is due to the incorrectness of man's economic activity. When man's activity leads to the destruction of the soil it is classified as agricultural, pasture, road and other types of erosion (15, 1). Pasture and agricultural erosion is distinguished in the forest-steppe district and there is some erosion on cut-over and burned areas.

Erosion on Cut-Over and Burned Areas

Forest fires have played an important role in Eastern Siberia in changing plant communities and thus in soil formation (9, 12); they have also often been a cause of erosion, as Krishtofovich (9) has also pointed out.

Fires destroy forest litter, mosses and grass and part of the undergrowth. This increases runoff. The soil, which is unprotected after the burning of the forest litter, is readily subjected to the eroding effect of the water flow. Runoff is also increased and concentrated by cutting of forest (19). Timber logging in cut-over areas also damages the soil. This damage may only affect the sod horizon or the whole soil profile down to the parent material. The ditch-shaped logging trails concentrate the surface runoff and thus lead to surface erosion.

The soils mainly subject to erosion as a result of forest fires and cuttings are those on steep sunny upland slopes with a gradient of between 10° and 20° or more.

Nikolayev (12, p. 76) connects the formation

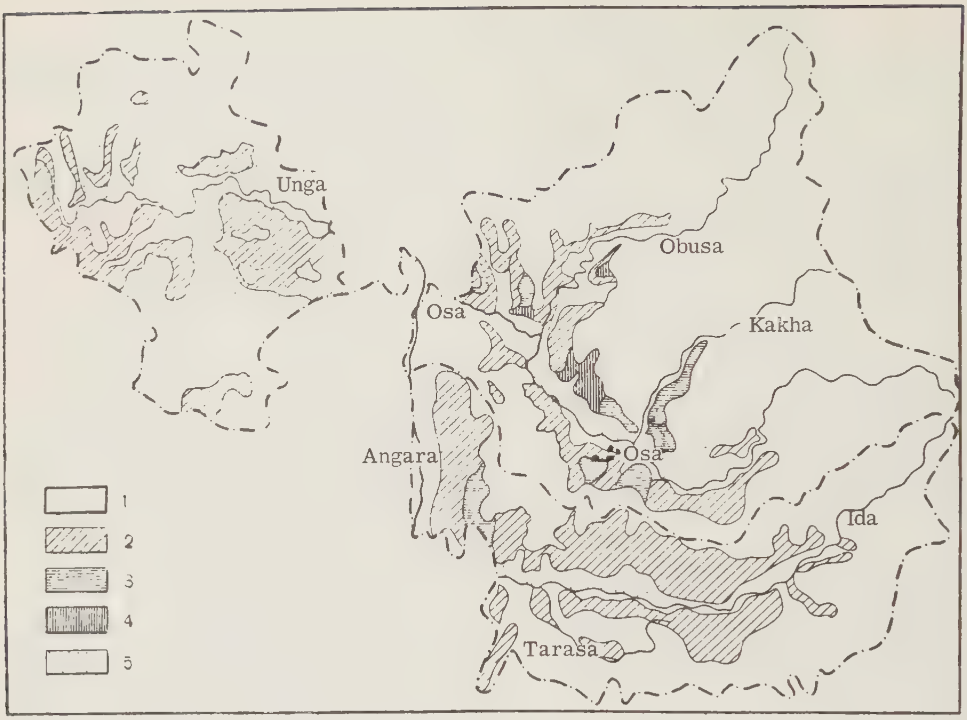

Fig. 1. - Distribution of eroded soils in the Osinskiy, Nukutskiy and Bokhanskiy districts of the Irkutsk region.

Distribution of eroded soils on plowlands.

1 - no erosion or less than 5% of the plowed area; 2 - 5%-15% of the plowed area eroded. Mainly slightly eroded soil; 3 - 15%-30% of the plowed area eroded. Predominantly lightly and moderately eroded soils; 4 - more than 30% of the plowed area eroded. Predominantly moderately and strongly eroded soils; 5 - districts of pasture erosion.

of shallow soils with the intensified washing away of fine earth on steep slopes. Since the term "Shallow" is a genetic attribute, it would be more correct to describe these soils as eroded.

The sod-carbonate weakly-podzolic soils on the upper sectors of slopes and watersheds are usually formed on the eluvium of upper Cambrian sandstones. They are silty coarse clay loams, containing up to 80% of silt particles (0.25-0.005 mm diameter [Okhotin's classification]) in the A_1 horizon and up to 86.5% in the A_2 horizon. These are less than 30% of water-stable aggregates >0.25 mm in diameter in the A_1 horizon. The water stability of many aggregates is due to root residues that attach to the soil particles. The structural aggregates are not mechanically stable and crumble to silt sizes when lightly compressed. It is mentioned in the literature (13) that these soils are easily erodible.

Soils, more or less developed under zonal conditions, have a developed sod A_1 horizon of 10-12 cm, cm A_2 horizon of 4-25 cm and a humus content of 6%-8% in the A_1 horizon. The depth of effervescence varies between 55 and 80 cm. Erosion reduces the thickness of the A_1 horizon or completely removes it and lowers its humus content to 2%-1%. The B horizon in eroded soils is normally gravelly. The depth of effervescence rises to 20-30 cm. The A_1 and A_2 horizons are often not defined in the soils, the illuvial horizon lies immediately beneath thin (1-2 cm) forest litter, and the parent material breaks the surface in places. These soils are found in the north and northeast of the Osinskiy district and in the east of the Bokhanskiy district. There is no point in subdividing them by level of erosion since there are large variations on small areas; in addition, these soils are not of great value for agricultural reclamation at the present time. We recommend that in large-scale soil mapping they should be classified as eroded or washed out if the surface has been more than 30% damaged by water erosion (visually assessed) and that the classificatory names and the gravel content of the soil horizons shoul be indicated.

Pasture Erosion

Animal husbandry has long been the main occupation of the indigenous population of the Angara and is still a very important branch of agriculture.

Animal husbandry is normally based on open eeless areas and river catch basins. Pasture osion therefore mainly affects chernozems, ich are the basic soil group of the Angara eppe. Deflation and water erosion of the l surface is prompted by a change in the ytocenoses and virgin surface of the soil a result of change in the phytocenoses and gin surface of the soil as a result of unregu- ed pasturing of animals.

First, vegetation is thinned out on areas that e too extensively used as pasture, on which nts develop that withstand grazing: feather ass, hard sedge, fringed sagebrush, milk ch, etc. As the soil is laid bare its upper rizon is dispersed by the hooves of the cattle l the lower horizons are compacted. This urally reduces the water permeability of the ls. Goroshkova (3) has pointed to the com- tion and drying out of the soil in the Balag- skiy forest-steppe as a result of the deteriora- n of pastures.

These changes affect the water regime of soils towards a seepage type, leading to sa- ization, since the parent materials are rich salts that are mainly sulfates. Salinization most marked on sunny slopes.

When surface gradients are slight (not more n 5°-6°) trampled paths are rarely formed. osion on these slopes is due to the fact that en pastures deteriorate the dispersed upper izon is easily accessible to eroding agents nd and water) since the vegetation is very nned out and stunted.

These soils have the following morphological ures:

a) removal of the upper horizons shortens the profile; b) the upper horizon is often highly dispersed and there is a clear transition to the underlying horizon; and c) the underlying horizon is compacted. When these soils are on medium and fine clay loams there is a great deal of cracking.

When the upper soil horizons are removed the total humus content is lowered, and the decline in the humus content on transition from the upper dispersed to the lower compacted horizon is directly proportional to the degree of erosion (Table 1). The boundary of effervescence normally reaches the surface, since the carbonate horizon approaches the surface (chernozems) as the upper layers are eroded, and since the seepage regime of these soils causes capillary ascent of carbonates.

Erosion is normally greatest on sunny slopes near inhabited points.

On the steeper slopes of ravines and river terraces (gradient 6° and above) trampled paths are also formed and the sod is disrupted when pasturing is excessive and the cattle are often driven over the same ground. Strips and patches of sod alternate with the exposed parent material. Similar destruction of the sod by trampled paths has been described by Sobolev (16), Izyumov (6), and Armand (1). Detailed classification of the stages of soil deterioration on steep slopes is based on the morphological attributes developed by Sobolev (16).

Places where the parent material is exposed are greatly dried out and subjected to intensive physical weathering and the loss of soil. Plants

Table 1

Humus content in soils subjected to pasture erosion

ro- ile No.	Soil and Stage of erodibility	Situation	Gradient, °	Horizon	Depth, cm	Humus, % (Tyurin's method)
306	Carbonate fine clay loam eroded chernozem	North-easterly slope below a gully	5	A_1	0—7	10,77
				A_2	7—21	6,80
				B	21—29	2,01
	1^1 stage[a]			C	30—40	0,78
308	The same 1^2 stage	South-westerly slope of a gully (lower part)	6	A_1	0—6	5,71
				A_2	6—19	4,28
				B	19—40	1,26
09	The same III stage	South-westerly slope of a gully (upper part). Terraced	11	A/B	0—10	3,52
				C_1	10—24	0,52
				C_2	24—35	0,21
92	The same III stage	Southern slope of upland. Not terraced.	6	A	0—12	4,06
				B	12—24	1,34
				C_1	30—40	0,76
15	Solonetz, deep effervescing fine clay loam chernozem Non-erodible	South-easterly slope	3	A	0—20	6,84
				B	20—31	2,87
				B/C	31—40	2,21
				C	40—60	0,97

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[a] Stage of erosion after Sobolev (16).

Note: Comma represents decimal point.

with a deep spreading root system (wormwood, milk vetch, etc.) are therefore planted around trampled paths.

The upper layer of the soil is normally greatly dispersed on trampled paths. Wind and water erosion are therefore especially intensive when trampled paths are formed and sheet erosion begins to give way to linear erosion.

On fairly compact parent materials (lower Cambrian dolomite limestones) this destruction of the sod causes mound formation. Formation of rills is encountered less frequently. The surface is greatly eroded and rills are formed on slopes when the sod is destroyed on loess-like clay loams and marls.

Pasture erosion is found in the east and southeast of Nukutskiy district, the west of Osinskiy district and especially on the right bank of the Osa and Ida Rivers in Bokhanskiy district.

Erosion of Cultivated Areas

Erosion has occurred in the Angara region since agriculture began. By 1890, 15% of the waste arable in the Balanganskiy area had been abandoned because of erosion. Eroded plowlands were rarely replowed but were normally used for pasture and were often grown over by forests. Eroded soils are most widespread where agriculture was first and most intensively practiced.

Plowlands subjected to erosional processes acquire the following main morphological features:

1. The color of the soil changes and becomes a lighter brown or red when the underlying soil horizons come closer to the surface;

2. Plow pan is often greatly developed on eroded soils of medium and fine texture;

3. The plowing horizon is compacted and the land becomes cloddy. Zemyatchenskiy (5) was the first to draw attention to these phenomena.

In our view these features are due to gradual addition of the plow pan to the plowing horizon as the latter is eroded and, on solonetz soil, by the compacted solonetz horizon approaching the surface.

The humus content and the nature of its distribution throughout soil profile is one of the important features of eroded soils. Soil fertility is largely determined by the physical and chemical properties of the humus horizon, since the main elements of plant nutrition are concentrated in it. Therefore the thickness of the humus horizon and its humus content are used as an important feature in the classification of the eroded soils. Sobolev (15), Shaposhnikov (20), Kozmenko (8), Surmach (18) and others have based classification on the thickness of the humus horizons.

The data in Table 2 show that the humus content in the plowed layer of eroded soil is greatly reduced. In slightly and moderately eroded soils this reduction is still insignificant, since, as the upper horizon is eroded, the transitional horizon that usually still contains sufficient organic matter, is plowed up. The sharp decline in strongly eroded soils is due to the plowing of the non-humus C horizon. Humus content below the plowing level in moderately and strongly eroded soils is very low.

One can find out the extent to which the lower genetic horizons are approaching the surface as the upper horizons are eroded and determine which horizon is being plowed up or included in plowing from the nature of humus distribution throughout the soil profile, especially when comparing the plowed horizon and the horizon below. One must also note an increase in the rate of dispersion in the upper horizons of erode soils owing to the high dispersivity of the soil-forming parent materials and to some decline in the clay content of the plowing layer.

The distribution of carbonates throughout the profile is one of the classificatory features of sod-carbonate deep effervescing soils and shallow chernozems. In eroded soils the carbonate horizon is often incorporated in the plowing layer or becomes the plowing layer when erosion is heavy. This sometimes causes soil scientists to classify eroded sod-carbonate soils as "typical" or highly effervescing.

The main difference between sod-carbonate leached (deep effervescing) and "typical" sod-carbonate soils is that effervescence in the humus horizon of "typical" soils is due to the presence of weathered fragments of the parent material and incomplete leaching of the carbonat from this horizon. In eroded, formerly leached soils the development of effervescence in the upp layer is due to incorporation by plowing of the carbonate horizon, which normally begins below the humus horizon in leached soils. Nikolayev (12), and Nadezhdin (11) point out that high effervescence of sod-carbonate soils is frequently associated with erosional processes.

We shall give a working classification of the eroded sod-carbonate cinnamon-brown leache soils and shallow chernozems that are most widespread in the districts. The existing classifications are scarcely applicable, owing to the extremely shallow soil profile and the peculiarity of structural profiles. The thickness of the humus horizons (A + B) is 40-50 cm in sod-carbonate soils and 38-40 in chernozems. In addition, the existing classifications of eroded soils normally relate to definite soil groups, whereas, as Presnyakova (14, p. 77), points out "no classification of eroded soils can be divorced from the genetic soil group."

Our classification scheme is based on the existence of genetic horizons and their alteration in the process of erosion. The classification is based on attributes which are genetic and which can be easily observed under natural conditions, and not on calculation of the amount of soil eroded, since this is difficult and in a number of cases impossible.

We used Sobolev's classification (17) when determining the stage of erosion of dark grey regraded and sod dark brown soils. Slightly

Table 2

Humus content. Particle size and microaggregate analysis (after Kachinskiy) in sod-carbonate shallow chernozems and sod-dark brown soils at an equal degree of erosion

Profile No.	Soil	Horizon	Depth, cm	Humus, % (Tyurin's method)	Particle diam. <0.001 mm	Microaggregates <0.001 mm in diameter	Coefficient of dispr. (after Kachinskiy)
				in %			
11	Sod-carbonate cinnamon-brown leached fine clay loam under forest (non-eroded)	A	3—19	4,32	33,5	3,1	9,3
		B	19—40	3,06	31,1	1,9	6,1
		B/C	40—55	1,32	22,0	4,9	22,1
		C_1	55—67	—	21,9	7,6	34,6
		C_2	67—87	—	28,3	4,4	15,5
5	Sod-carbonate cinnamon-brown fine clay loam plowland, slightly eroded	A/B	0—10	4,10	28,3	4,4	13,1
		A/B	10—25	3,93	33,6	4,4	17,2
		B/C	25—35	2,01	38,4	6,6	26,0
		C	40—55	1,07	30,0	7,8	26,0
45	The same, moderately eroded	A/B	0—18	3,85	34,1	1,8	5,3
		B/C	18—24	2,08	37,0	2,8	7,6
		C_1	25—35	0,80	26,0	4,9	18,9
197	The same, strongly eroded	A/B/C	1—15	2,75	23,8	5,5	23,1
		C_1	21—40	0,58	19,1	5,8	31,0
		C_2	80—90	—	16,8	6,6	39,1
7	Shallow solonetz, deep effervescing, fine clay loam chernozem. Plowed non-eroded	A	0—20	8,16	29,3	1,4	4,7
		B	25—35	3,38	22,8	2,7	11,8
		C	45—55	0,90	29,0	3,3	11,4
55	The same, slightly eroded	A/B	0— 5	4,32	32,7	1,3	5,3
		A/B	5—16	4,25	33,4	2,0	6,0
		B	16—30	2,30	34,2	2,3	6,1
		C_1	40—55	0,97	29,2	2,7	9,2
		C_2	60—70	—	23,4	4,4	18,8
56	The same, moderately eroded	A/B	0— 5	3,32	32,0	2,4	6,2
		A/B	5—18	3,22	37,9	3,8	10,5
		C_1	20—30	1,00	29,5	4,9	16,6
52	The same, strongly eroded	A/B/C	0—20	1,83	30,0	4,1	13,7
		C	22—40	0,74	31,4	4,9	15,6
179	Sod dark brown, fine clay loam under forest, non-eroded	A	0— 14	3,92	31,8	3,5	11,1
		A/B	14— 28	2,48	34,7	4,4	12,7
		B	28— 41	1,16	29,2	4,2	14,9
		B/C	41— 55	0,68	25,2	4,2	16,6
		C_1	75— 80	—	15,4	3,0	19,5
		C_2	105—120	—	20,7	5,7	28,0
155	Sod dark brown, fine clay loam. Plowland, slightly eroded	A	0— 18	3,28	27,1	2,8	10,2
		B	18— 27	2,39	29,2	5,3	18,2
		B	27— 34	1,39	32,0	7,9	24,3
		C_1	50— 60	0,94	31,3	6,6	21,1
		C_2	90—100	—	30,2	4,2	13,8
158	The same, medium eroded	A/B	0—28	1,90	32,5	5,6	17,2
		B/C	25—35	1,21	31,6	5,0	15,8
		C_1	35—45	0,61	29,3	4,0	14,1
161	The same, strongly eroded	A/B/C	0—24	1,93	26,6	3,9	14,7
		C_1	24—28	0,95	33,8	5,0	14,8
		C_2	30—50	0,76	31,6	3,5	1,9
		C_3	70—90	—	11,6	2,3	21,5

Note: Comma represents decimal point.

Table 3

Classification scheme for eroded soils

Stage of erosion	Sod-carbonate cinnamon-brown steppe deep effervescing soils	Shallow leached chernozems. Shallow solonetz deep effervescing chernozems
	Attributes by which the soils are subdivided by the stage of erosion	
Slightly eroded	The B horizon is plowed in when plowing to a depth of 20-22 cm. Transition from the plowed layer to the layer beneath can be seen from the color.	B horizon plowed in when plowing to a depth of 20-22 cm. Compacted beneath plowed layer. Transition from plowed layer to layer beneath seen from color and compaction.
Moderately eroded	B horizon plowed in fully when plowing to a depth of 20-22 cm. Always effervesces in the upper part of the horizon beneath the plowing layer, sometimes weakly in the plowing layer, plow pan often found. Transition from plowing layer to layer beneath clear from color.	B horizon totally plowed in when plowing to a depth of 20-22 cm. The lower part of the plowing layer and the upper part of the layer beneath are normally compacted, especially on solonetzic chernozems. Tongues are normally found in the layer beneath. Effervesces in the layer beneath and sometimes in the plowing layer (in solonetzic chernozems). Transition from the plowing layer to the layer beneath clear from the color. Plow pan found.
Strongly eroded	Horizon BC plowed in when plowing to a depth of 20-22 cm. The plowing layer is compacted and cloddy. Always effervesces from the surface downwards.	BC horizon plowed in when plowing to a depth of 20-22 cm. Effervesces almost everywhere from the surface downwards, but sometimes from 5-10 cm. Tongues absent from the layer beneath the plowing. Plowing layer compacted.

eroded soils normally occupy sectors of slopes, the gradient of which exceeds 3°-4°. Moderately eroded soils are found on 5°-7° slopes that have been cultivated for a fairly considerable length of time.

Strongly eroded soils are found on 7°-12° steep slopes that are usually greatly gullied. In addition to the size of the gradient, soil erosion is also influenced by the configuration of the fields on the slope, which is often determined by the direction of plowing. The most strongly eroded soils are therefore often found on plowed lands that extend along the slope rather than on those with the same gradient that run across the slope.

Conclusions

1. The natural conditions of the territory favor the development of erosional processes.

2. Accelerated erosion is intimately associated with man's effect on the vegetation and the soil (decrease in the area under forest, unregulated pasturing of cattle and plowing without measures to control erosion).

3. Unregulated grazing of cattle causes the deterioration of pastures, dispersion of the upper soil layer and the formation of trampled paths, all of which taken in toto cause deflation and soil erosion.

4. Cultivation greatly increases the area of eroded soil. The critical angle of slope for the development of erosion is 3°-4°. A decrease in the humus content is a typical feature of eroded soils, as is an increase in the content of carbonates in the upper horizons in sod-carbonate leached and shallow chernozems.

5. Erosion is a real threat to the rapidly developing agriculture of the region and the whole agricultural area must therefore be studied to reveal the foci of erosion and to develop measures for controlling it.

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DYNAMICS OF MICROBIOLOGICAL PROCESSES IN THE RED EARTHS OF TEA PLANTATIONS IN SOVIET GEORGIA

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The red earths of the Georgian humid subtropics have favorable physical properties, good macro- and micro-structure, and high porosity and water permeability. Under normal conditions these soils have a considerable humus content (6%-7% on average and up to 10% in some cases). Their reaction varies between pH 4.0 and 5.5. The high temperature and moisture and good aeration of the soils ensure that the organic matter is highly mineralized; under known conditions this process becomes intensive and the red earths are depleted of organic matter.

All these factors govern the specific course of microbiological processes in red earths.

The first data on the number of microorganisms in red earths were obtained by Kuznetsov (11); the figure varies between 1300 and 1800 m per 1 g of soil (Hermann's method).

The physiological groups of microorganisms in red earths were first studied by Garder (1), Shvetsova (14), Zakharova and Obraztsova (6), Isakova (7), and Saakashvili (12). These studies did not, however, deal with such fundamental aspects as the seasonal dynamics of the main physiological groups, the species composition of the microflora of red earths, the effect of the developmental stage and age of the tea shrub, cultivation, fertilizers and a number of other factors.

We have been engaged since 1946 in the systematic study of the microflora of red earths in the soil-plant-microorganisms system. These studies have led to a number of conclusions (2,3, 4).

Our studies of the soil from the root zone of the tea shrub and of the soil outside the plant showed that the microflora of the rhizosphere of the tea shrub differs both quantitatively and qualitatively from the microflora of the soil outside the plant. The number of microorganisms in the soil is counted in thousands per 1 g, but in the root zone this figure is tens of millions per 1 g of soil. In the immediate vicinity of the roots there is a numerical increase in the ammonifiers and dentrifiers and in azotobacter.

A study of the seasonal dynamics of the microflora in red earths shows that its quantitative and qualitative composition changes during the growing season and that the largest numbers of microorganisms are found in the autumn when the tea shrub is flowering.

The microflora of the rhizosphere is clearly formed at quite early stages in the development of the plants, since the values are of the same order for seedlings a few months old (several millions of microorganisms per 1 g of soil) as in 2-3 year plants. The number of microorganisms in the rhizosphere for seedlings in the first year of growth on meat-peptone-agar is 34 million, reaches 95 million in 2-3 year plants and decline to 65.5 million in fullgrown 10-12 year plants. Thus, the amount of microorganisms show a tendency to decline with the growth of the shrubs. There are also changes in the qualitative composition of the microflora in the rhizosphere; in the autumn, for example, there is a decrease in the total of florescent forms and an increase in yellow pigmented form etc.

A comparison of the species composition of microorganisms in the soil and the rhizosphere of a tea shrub shows that whereas the soil is characterized in the main by such microorganisms as *Bacillus mesentericus*, *B. cerius*, *B. mycoides*, *B. virtulus*, etc. and by various pigmented species such as *Micrococcus flavus*, *Sarcina subflave*, etc., the microflora of the roots and surrounding areas is represented in t main by small nonsporogenic rods, including th species *Pseudomonas shuylkiliensis*, *P. fluores ceus*, *B. dachune*, *B. desmolyticum* and *B. agi*

Among the main representatives of the micro flora of the rhizosphere we discovered organisms with a stimulating effect on the development of the tea shrub in a pot experiment — *B. agile* that reduces nitrates to nitrites and is present in large amounts on the roots of the tea plant is one such growth stimulator.

The rhizosphere of the shrub also contains microorganisms that are antagonists to *Fusarium sp.* which protect plants on tea plantations from infection by *Fusarium.*

In later studies we attempted to show the effect of cultivation, the use of fertilizers and the plant itself on the microflora of red earths

Table 1

Data on soil characteristics and plant yields, on the treatments studied

eat-ent fo.	Treatments	Dry residue, mg/l	Acidity		Humus, %	Growth of green mass of tea leaf
			Exchange-able, meq.	pH of a water sus-pension		
	Without tea plant					
I	Virgin soil	82,0	3,1	5,2	6,2	—
II	Cultivated	98,0	4,3	4,3	3,53	—
II	Cultivated + NPK	252,0	5,9	4,2	3,87	—
	With tea plant					
IV	Control (without fertilizer)	72,0	5,1	4,8	4,51	185
V	N	128,0	6,1	4,2	4,12	325
VI	NP	201,0	6,8	4,0	5,51	445
II	NPK	216,0	6,9	4,0	5,03	513
II	NPK + Ca	300,0	6,1	5,5	4,25	1075

e: Comma represents decimal point.

for tea cultivation. We studied the soil rmanent experimental plots of the All- ı Research Institute for Tea and Sub-tropi- lants which were started in 1953. The samples were taken from experimental ments according to the following plan: a s without tea plants: I — virgin soil, II — vated to 45 cm depth and III cultivated + NPK; ies with tea plants: IV control (without izer), V — application of N, VI — NP, NPK and VIII — NPK + Ca[1] (Table 1).

valuation of the acidity (pH of a water sus- on) of the soils in the different experi- al treatments showed that both cultivation he special application of mineral fertil- containing nitrogen in the form of am- um sulfate lowered the pH of the soil um.

ble 2 gives data for the number of micro- nisms on meat-peptone-agar, on Chapek's um and on a medium for spore-formers; e treatments with and without plants the cation of NPK increased the number of oil microflora. It should be noted that is no such precise correlation between oplication of fertilizers and the number croorganisms as there is between fertil- and plant yield. It is clear that the app- on of a complete mineral fertilizer NPK sifies microbiological activity as a whole oes not affect all groups of microbes y.

en we compare analyses of soil from the sphere in the different experimental treat- for different periods we see that the qualitative composition of the microflora is altered.

The microflora is usually most diverse in the following treatments: virgin — I, NPK — VII and NPK + Ca — VIII. In the autumn fungi predominated on the treatments with ammonium sulfate (III, V, VI, VII), bacteria were most plentiful on the virgin soil — I and NPK + Ca — VIII treatments B. mycoides was only found on the virgin soil.

In the spring there was a large amount of B. mycoides, that developed on plates strewn with soil from all the experimental treatments, mainly treatments I and VIII. There was little fungi flora.

In the summer (August) small pigmented forms (mycobacteria) predominated. There is a wide range of spore-formers but type No. 5 — B. mesentericus clearly predominated in the majority of treatments and B. mycoides in the virgin soil, control and NPK + Ca treatments. The NPK + Ca treatment contained a large amount of actinomycetes, amounting to 26.5% of the over-all total at this time. It is worth noting that B. mycoides is almost invariably found in treatments with the plants.

The bacteria, fungi and actinomycetes were counted on Chapek's medium. The total number of microbes on this medium was greatly reduced in treatment V which had only received nitrogen as sulfate of ammonia and increased in treatment VIII which had received Ca.

Differences in qualitative composition were even more clearly defined on this medium: bacteria predominated on treatments without fertilizer (I, II and IV) while molds of the genus Penicillium predominated on the treatments with mineral fertilizers. Bacteria only grew on treatment VIII which had received lime with NPK. Thus the application of mineral fertilizers greatly affects the nature of the microflora that

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ıust be stated that with this scheme one can ompare treatments that are identically culti- (deep plowing to 45 cm). One can make only a onal comparison for the virgin soil where the horizon is retained undisturbed.

Table 2

Total quantity of microorganisms in soils of the different experimental treatments in 1,000's per 1 g of soil

Treatments	pH water			On meat-peptone-agar						On MPA + must-agar						On Chapek's medium					
	1957	1958	1959	1957	1958			1959		1957	1958			1959		1957	1958			1959	
				18.XI	7.IV	2.IX	6.XI	25.V	20.VI	18.XI	7.IV	2.IX	6.XI	25.V	20.VI	18.XI	7.IV	2.IX	6.XI	25.V	20.VI
Series without tea plant																					
I. Virgin soil	5,3	5,2	4,7	320	2200	9400	6200	7200	7200	49	250	330	320	390	350	4450	3500	5380	10000	5200	4100
II. Cultivated	4,3	4,3	4,1	860	2000	7300	4600	6000	5100	130	110	190	260	290	380	3620	5400	2560	8000	3400	2100
III. Cultivated + NPK	4,2	4,2	4,1	880	4800	6000	5700	3600	1900	7	90	540	430	500	260	4170	3000	5000	12000	9900	2800
Series with tea plant																					
IV. Control (without fertil.	4,8	4,8	4,8	290	2600	3400	3300	5000	3100	46	130	240	180	240	220	3970	3300	6360	10000	8800	700
V. N	3,8	4,2	3,8	360	1700	—	—	—	—	32	80	—	—	—	—	500	500	—	—	—	—
VI. NP	3,8	4,0	3,6	310	1700	—	—	—	—	9	40	—	—	—	—	650	3500	—	—	—	—
VII. NPK	3,7	4,0	3,6	630	7000	7200	5600	10 900	4500	14	40	620	250	50	240	250	4000	9000	22000	6100	1500
VIII. NPK + + Ca	3,9	5,5	4,1	690	7200	8900	11 000	8000	5000	12	60	100	210	110	100	520	4200	10800	22000	6400	6500

Note: Comma represents decimal point.

lops on a given medium.

onsideration of the dynamics of the physio- cal groups of microorganisms in the micro- ı of red earths shows the following. There on the average up to 5 million ammonifiers g of soil: no large differences were ob- ed in their content in the different treat- ts. There were tens or hundreds of thousands nitrifiers on one g of soil. The number of de- fiers was highest on the virgin soil and the tments with NPK and NPK + Ca: gas was rarely found, mainly when lime was ap- l. There are 10-10,000 nitrifiers in 1 g of earths and the number increases when eral fertilizers are used. From 10% to of the sliming crumbs of soil on plates of gradskiy's silica gel are Azotobacter in earths. The most common species is one e to Azotobacter indicum; Azotobacter ococcum is found at times on the virgin and in the plant without fertilizer treat- :, i. e., where there is no acidification due mmonium sulfate. The quantity of Azotobacter s on the roots of the tea plant. Clostridium eurianum is widely distributed in red earths, e there may be hundreds of thousands in g of soil. The number of cellulose-de- posing bacteria in red earths is insignifi- , being only 10-100 and rarely as much ,000 in one g of soil. They are mostly d in virgin soil and on the NPK + Ca treat- :, which are mainly fungi.

xamination of the data in Tables 3 and 4 for hysiological groups of microorganisms ed that the application of complete mineral lizer mainly increases the number of nitri- and aerobic cellulose-decomposing bacteria.

'e also studied the effect of organic fertilizers ed as manure to red earths. The microbio- al studies were conducted on another series periments at the Tea Research Institute on lan: 1. control (without fertilizer), 2. NPK 3. NPK + manure.

he analytical data show that manure has a marked effect than mineral fertilizers on oil microflora. As Table 5 shows, the number of microorganisms by comparison the control increased in all three media — , MPA + must-agar and Chapek's medium. e is also a numerical increase in a number ysiological groups of microorganisms, ly nitrifiers and aerobic cellulose-decom- ıg bacteria when manure is applied.

ıus the organic matter added as manure is ditional factor, as well as the pH value, termining the number of microflora in arths.

ıe specific features of the red earths have greatest effect on such microbiological esses as nitrogen fixation and dentrifica- We must therefore dwell in greater de- n the features of these two processes in ed earths.

nce we have devoted a special article to itrogen fixation we shall mention only the es of red earths by Garder (1), Shvetsova Zakharova and Obraztsova (6), Isakova nd Saakashvili (12), who either failed to detect nitrogen-fixing bacteria or found that they were very poorly developed. Our studies showed that a typical feature of the development of nitrogen-fixing bacteria in red earths is that despite their high acidity various species of Azotobacter develop in them, the most frequently encountered species being A. indicum, which is best adapted to low pH values of the media.

Our experiments showed that apart from soil reaction, the existence of a number of bacteria in the soil that are antagonists is a limiting factor on the development of azotobacter in red earths. Such bacteria were isolated and their antagonistic properties were studied. A. indicum which is most frequently discovered in red earths, had the least number of antagonists.

Apart from the high Azotobacter content, red earths also contain a considerable number of C. pasteurianum, which clearly plays an important part in nitrogen-fixation.

We shall deal briefly with the process of denitrification in red earths. Owing to the unfavorable reaction of the soil medium (pH 4.0-5.0) this process proceeds quite slowly. Absence of gas formation is a specific feature: one must assume that the gas-forming denitrifiers are here poorly developed. The process goes only as far as the formation of nitrites; free nitrogen is not usually formed. On the few occasions when the gas is detected it is mainly when lime has been applied. Daneliya gives similar data on denitrification in red earths (5).

There are numerous data in the literature to show that denitrifiers form part of the leading group of microflora in the rhizosphere for the majority of agricultural crops. As long ago as 1934 Krasilnikov pointed out that the existence of a large quantity of denitrifiers on the rhizosphere of many plants casts doubt on their harmful effect on them. In preceding papers I have also noted a great increase in the number of denitrifiers on the tea plants.

On the basis of Shmuk's data, which show that the roots of higher plants can obtain nitrogen as nitrites as well as in the form of nitrates, one can advance the hypothesis that the large number of denitrifiers on the roots of the tea plant that reduce nitrates to nitrites, play a positive and not (as was generally though) a negative role, and that in red earths the denitrifying process should not be seen as a negative phenomenon since it is not associated with losses of molecular nitrogen. I am convinced of this from the data of my own pot experiments, which were set up to reveal the influence of the main components of the rhizosphere's microflora on the development of a tea shrub. In this experiment the best plant growth was obtained in vessels to which B. agile (that causes active denitrification) extracted from the root of a tea plant had been added.

Many investigators concerned with the rhizosphere of agricultural plants are studying the role of denitrifiers in plant nutrition. Laboratory experiments conducted by Kruglov (9) under Berezova's direction at the Moscow Department of the All-Union Institute of

Table 3

Group composition of the microflora of red earths

Treatments	Ammonifiers in 1,000's/g of soil						Denitrifiers in 1,000/g of soil					
	1957	1958			1959		1957	1958			1959	
	18.XI	7.IV	2.IX	6.XI	25.V	20.VI	18.XI	7.IV	2.IX	6.XI	25.V	20.VI
I. Virgin soil	5000	500	5000	5000	5000	10000	500	50	10	1000	1000	10000
II. Cultivated	1000	1000	5000	1000	10000	10000	100	<50	10	100	10	10
III. Cultivated + NPK	5000	500	5000	1000	5000	100000	100	<50	50	1000	<10	50
IV. Control (without fertil.)	5000	500	5000	5000	100000	100000	<100	<50	5	100	1000	10
V. N	1000	500	—	—	—	—	<100	<50	—	—	—	—
VI. NP	5000	500	—	—	—	—	500	50	—	—	—	—
VII. NPK	100	5000	1000	5000	5000	5000	100	<50	5	500	1000	50
VIII. NPK + Ca	100	5000	5000	100000	5000	1000	500	50	100	1000	50	10
	Nitrifiers						Cellulose-decomposing bacteria					
I. Virgin soil	0	10	100	100	0	1000	100	Not det'd.	50	100	100	1000
II. Cultivated	10	10	0	10	0	10	50	"	5	10	10	100
III. Cultivated + NPK	0	5	0	0	0	0	5	"	10	100	10	10
VI. Control (without fertil.)	0	5	10	10	50	0	10	"	10	0	10	100
V. N	Not det'd.	50	—	—	—	—	—	"	—	—	—	—
VI. NP	"	100	—	—	—	—	—	"	—	—	—	—
VII. NPK	0	100	100	100	100	100	100	"	50	50	10	100
VIII. NPK + Ca	10	100	10000	1000	1000	1000	100	"	1000	100	500	100

Note: Comma represents decimal point.

Table 5

Effect of applying fertilizers on microflora of red earths in 1,000's per 1 g of soil

Treatments	No. of microorganisms											
	Meat-peptone-agar				MPA + must-agar				Chapek's medium			
	1958		1959		1958		1959		1958		1959	
	May 8	June 5	May 25	June 20	May 8	June 5	May 25	June 20	May 8	June 5	May 25	June 20
ontrol	1400	1900	5200	2200	310	500	550	300	11000	1400	3700	4600
PK	4200	1900	5800	2600	280	500	240	450	3800	1540	2000	4300
PK + Manure	5300	3000	10300	2800	320	1700	460	220	11800	2660	2900	4600

Physiological groups

Treatments	Ammonifiers				Denitrifiers				Nitrifiers			
	1958		1959		1958		1959		1958		1959	
	May 8	June 5	May 25	June 20	May 8	June 5	May 25	June 20	May 8	June 5	May 25	June 20
ontrol	10000	100	1000	5000	10	10	100	50	0,05	0,01	0,01	0
PK	10000	1000	5000	5000	100	100	100	50	0,1	0,01	1,0	0
PK + Manure	10000	1000	5000	5000	100	100	500	10	0,1	0,1	1,0	0

Physiological groups

Treatments	Clostridium pasteurianum				Azotobacter, %				Cellulose-decomposing bacteria			
	1958		1959		1958		1959		1958		1959	
	May 8	June 5	May 25	June 20	May 8	June 5	May 25	June 20	May 8	June 5	May 25	June 20
ontrol	1000	5000	1000	500	10	20	54	25	0,1	0,5	0,01	0,01
PK	5000	5000	5000	1000	52[a]	39	65	15	0,05	0,5	0,01	0,5
PK + Manure	10000	5000	5000	5000	54[b]	53	55	29	0,1	0,1	0,1	1,0

[a] Slime consisting of clostridium cells

[b] Mainly Azotobacter cells

ote: Comma represents decimal point.

cultural Microbiology have demonstrated ole of denitrifiers as producers of a numf vitamins — thiamine, tyridoxine, and thenic acid. These data show that denitri- may possibly play a part in supplying s with vitamins. They thus do something plain our data on the stimulating effect nitrifiers on the tea plants.

ecent work by Kruglov (10) has demonstrated le of denitrifiers as producers of ammonia mproves plant growth. It has also been vered by Stepanova (13) that denitrifying bacteria stimulate the multiplication of Azotobacter and thus intensify the process of nitrogen-fixation.

Conclusions

1. Red earths have a comparatively low microorganism content, a comparatively high content of ammonifiers, poorly developed nitrifiers and cellulose-decomposing bacteria and a well-developed fungi flora.

Table 4

Group composition of the microflora of red earths

Treatments	Clostridium pasteurianum in 1,000's per 1 g of soil						Azotobacter on gel (%)						
	1957	1958			1959		1957	1958			1959		
	18.XI	7.IV	2.IX	6.XI	25.V	20.VI	18.XI	7.IV	2.IX	6.XI	25.V	20.VI	29.VI
I. Virgin soil	10000	1000	500	1000	500	5000	11[b]	23[b]	24[b]	25[b]	87[b]	5	22[c]
II. Cultivated	1000	1000	100	1000	1000	<1000	20	27	15	10	39	7	16[b]
III. Cultivated + NPK	500	500	100	100	10000	<1000	3	21	12	2	58	18	26[c]
IV. Control (with -out fertiliz)	1000	1000	500	1000	10000	5000	3	10	13[a]	12[a]	63	14	5[c]
V. N	500	1000	—	—	—	—	5[c]	11	11	2	—	—	46[c]
VI. NP	1000	1000	—	—	—	—	3	25[a]	23	3[a]	—	—	23[c]
VII. NPK	1000	1000	100	5000	500	5000	9	14	17	2	3[c]	14	24[c]
VIII. NPK + Ca	1000	500	100	5000	500	5000	6	23[c]	18	0	19[c]	18	32[c]

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[a] Slime typical of Azotobacter indicum

[b] Watery, untypical slime consisting of commensal rods of Azotobacter

[c] Clostridium pasteurianum is present

Note: Comma represents decimal point.

2. There is a direct relationship between the reactions of the soil medium and the quantitative and qualitative composition of the microflora in the red earths. Acidification of the soil from the application of a physiologically acid salt ammonium sulfate — suppresses certain groups of microorganisms.

3. The application of organic fertilizers in the form of manure together with mineral fertilizers has a positive effect on the number and composition of microflora in the red earths.

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METHODS

OGEOCOENOTIC RELATIONSHIPS BETWEEN THE NODULE BACTERIA ID THE LEGUMES (DNIEPER BROOM AND WHITE ACACIA) I OLESH SANDS

GORDIENKO

he main life-regulating factors at work on Olesh sands are drought, wind erosion and activity of insects; of these, the last named ie most important in terms of the diversity s effects. On the one hand, the long-term ral process by which denuded shifting sands ome overgrown depends on the insect popu- on (2), which limits the forestation process ands which have already been grown over to e extent; on the other hand, the insects con- ite one of the main factors in promoting soil nation on these sands (1). The insect a, however, also determines the rate at h nodules form on the roots of legumin- plants growing in the hilly Olesh sands.

n 1953-57 we studied nodule formation on s of the Dnieper broom (*Cytisus borysthen-* Grün) and white acacia (*Robinia pseudo- ia* L.) in the Kazach'ye-Lagerskaya and h'ye areas of the Lower Dnieper under vari- habitats: denuded, well overgrown, yellow, is-free and grey humus sands with and with- ouried soil or clay loam interlays within root layer, and also in transitional types of hese habitats. Nodule counts were made in)-10, 10-25, 25-40, 40-60, 60-80, and 80- cm layers and every 25 cm in the 100-125 ayer and below to a depth of 2 m. Digging continued to even greater depths so long as valls of the trench held. Trenches were dug er at places where the top of the trench d be adjacent to the trunk of a white acacia or at the center of a broom thicket. The of the trench was one-eighth of a circle 6 diameter in the first case and a quarter or eighth of a circle 4 or 6 m in diameter in second case, depending on the size of the b. Five to seven replications were made. method used for counting the *Lamellicornia* al population was to dig 1 m² of soil layer yer and carefully pick out the larvae by hand. depth of the trench was 1 m. For each at type 70-100 replications. An insect ratus for counting was made by enclosing umn of sand to the depth at which excre- was still found (5-15 cm) with a bottomless der of known area (about 1 cm²) specially ufactured for the purpose. Forty to fifty cations were made. The excrement was rated from the sand by sieving followed by ing out with water.

was found that extensive nodule formation 1.0 g per m²) occurred on the roots of Dnieper broom growing on sands free of organic matter. Nodule formation was much more (10-12 times) intensive in sand layers containing even negligible amounts of microbiologically active excrements of the *Orgyia evicae* Germ. caterpillar and the larvae of leaf-horned beetles (the sand beetle *Anomala errans* F., the weevil *Anthonoma dutai* Scop., the grain beetle *Anisoplia austriaca* Herbst., the weevil *A. segetum* Herbst., the cockchafer *Monotropus nordmanni* Blanch., the marble beetle *Polyphylla fullo* L., the long-haired beetle *Epicometis hirta* Pod. and the Dnieper bronze beetle *Potosia jeeberi borysthenica* Med.), the wormwood moth caterpillar *Melicleptria scutosa* Schiff or the larvae of fly *Bibio marci* L., than in the excrement-free sand layers.

The relationship between nodule formation and the amount of excrement from the larvae of the foregoing species in the sub-stratum is particularly marked in the case of the white acacia. Nodules form just as extensively (0.4-0.6 g per m², columns 2 and 4 of Table 1) on the roots of this tree in denuded humus-free sand containing no insect excrement as on the roots of the Dnieper broom under identical habitats. On acacia roots in humus-free sand containing 400-700 g of insect excrement per m² in the top 15-17 cm layer, 7-14 g of nodules form over the same area in that layer (columns 3 and 5). On acacia roots growing on grey humic sand and containing 700-800 g of soil insect excrement per m² in the top 12 cm layer (0.4% of the excremental matter in that layer) there is even more intensive nodule formation (see Fig. 1), amounting to more than 80 g per m² in that layer (column 6).

As can be seen, the insect population is a major producer of energy-supplying material for the nodule bacteria, for it is a link in the change of interrelationships between these and the leguminous plants.

Other groups of microorganisms, too, use insect excrement as a source of energy. According to figures produced by the Institute of Forestry, Academy of Sciences, USSR, there are in all 40,000-80,000 saprophytic bacteria in 1 g of humus-free quartz sand containing no *Lamellicornea* larvae excrement, taken from a semi-overgrown area, whereas 1 g of the same humus-free quartz sand containing soil inverte-

Table 1

Relationship between number of nodules on white acacia roots and the amount of excrement contained in the sub-stratum of the soil

Depth, cm	Olesh'ye (ground waters at 5-8 m depth)				Poles'ye (ground water at 2.5-3.0 m depth)	
	Humus-free sand				Grey humidified sand with a buried soil layer (chernozem-like sandy loam at depth of 90-160 cm)	Cryptopodzolic coarse clay loam on sand
	Single phase		Buried layers			
			Soil (at 75-130 cm depth)	Clay loam (below 142 cm)		
	Excrement-free	Excrement 0-50 cm layer	Excrement-free	Excrement in (col. 5) 0-60 cm layer (col. 6) 0-30 cm layer		Humic layer (h = 15 cm)
				0—60 см	0—30 см	
1	2	3	4	5	6	7
Amount of excrement (air dry), g per m²						
0—17	—	338	—	—	—	—
0—15	—	—	—	733	—	—
5—17	—	—	—	—	778	—
Amount of nodules (in fresh condition), g per m² (average of 5-7 trenches)						
0—10	0,03	0,47	0,18	3,35	51,12	19,50
10—25	0,06	2,86	0,01	5,78	31,38	3,53
25—40	0,01	2,55	0,02	2,15	0,50	0,71
40—60	0,06	0,66	0,07	2,63	0,23	1,45
60—80	0,16	0,09	0,92	0,09	0,07	0,67
80—100	0,01	0,08	2,57	0,12	0,13	0,39
100—125	0,06	0,19	1,24	—	1,17	0,20
125—150	0,03	0,16	0,29	0,52	0,62	—
150—175	—	0,05	—	12,30	0,08	—
175—200	—	0,11	—	7,56	—	—
200—225	—	—	—	14,41	—	—
Total	0,42	7,22	5,30	49,31	85,30	26,51
kg/ha	4,2	72,2	53,0	493,1	853,0	265,1

Note: Comma represents decimal point.

brate excrement, taken from a well-overgrown area, contains more than 3 million of these bacteria or 40-80 times more than in the first soil.

A further factor influencing the relationship between the rate of nodule formation on legume roots and the abundance of nodule bacteria cells in the sub-stratum is that inoculation of the legumes with these microorganisms is not effective in very poor soils that do not contain the minimum of energy-producing material, which as we mentioned previously, is the first essential for the development of the nodule bacteria themselves.

The rate of nodule formation on white acacia roots in a moist layer of sand containing a good deal of Lamellicornea larvae excrement (Table 1, column 6), is more than three times higher than the Poles'ye soils referred to in column 7 of Table 1. This indicates that in addition to mineral nutrients (phosphorus, potassium and so forth) organic matter (amorphous humus) in the sub-stratum is also of great importance for the development of nodule bacteria and so for nodule formation. Soil moisture is of secondary importance, although in conjunction with organic matter it is an important factor in determining the rate of nodule formation on legume roots.

As can be seen from the foregoing, our values are not in agreement with the theories of Chaylakhyan and Megrabyan (4), and of Fedorov and Kozlov (3), to the effect that the rate of nodule formation on legume roots depends on the physiological condition of the plants. In the opinion of these investigators the degree of inoculation of the legume roots by nodule bacteria (Rhizobium Frank), and therefore also the rate of nodule formation, depends on the soluble nitrogen compound content in their tissue. This means that bacteria can appear in the root, and that nodules can thus be forme only when there is a low concentration of nitrogen compounds in the root cells, and that inoculation of the roots by nodule bacteria, with the consequent formation of nodules is impossible where the nitrogen compound concentration is high.

g. 1. - Intensive nodule formation on white acacia roots in sand layer containing abundant insect excrement

ylakhyan and Megrabyan on the one hand
Fedorov and Kozlov on the other differ in
the former believe inoculation by nodule
eria to be impossible also in a nitrogen-
ved part of the root, whereas the latter
k that a sufficient supply of bonded nitro-
to one part of the root will not effect the
ulation, by nodule bacteria, of another
of the root of the same plant which is not
lied with nitrogen nutrients.

f root incoculation by nodule bacteria, and
equently nodule formation, were to depend
he physiological condition of the plant, the
per broom and white acacia, and indeed
eguminous plants growing on denuded
us-free quartz sand would lack intensive
le formation on their roots as a result of
ow concentration of nitrogen compounds in
root cells and the consequent low resistance
e plant to invasion by nodule bacteria. As
e 1 shows, however, this is not observed in
nature. Nodule formation is very slight on white acacia and Dnieper broom growing on bare, clean quartz sand. A further point which does not agree with the theory referred to is that nodule formation on white acacia roots in the vertical direction is not uniform; but instead of being more intensive in that part of the root which is in a sub-stratum free of insect excrement, as we should expect if the legume root inoculation by nodule bacteria depended on the physiological condition of the plant, it is more intensive in that part of the root which is situated in layers abounding in insect excrement and therefore much richer in mineral nutrient elements.

It follows that the rate of nodule formation on legume roots depends not on the physiological condition of the plant but is a direct relationship to the number of nodule bacteria cells in the soil. The abundance or the lack of bacteria determines the degree of probability of legume root inoculation. The abundance of such cells in the soil is in turn a function of the richness of the soil in organic matter and, it would seem, in mineral nutrients. Insofar as the main form of organic matter accumulation in the process of soil formation on the Olesh sands is the excrement of soil invertebrates and certain other insect fauna groups (1), it follows that the rate of nodule formation on the roots of the leguminous plants mentioned depends on the amount of excrement from these animals in the sub-stratum.

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IS PHOSPHORITE BROKEN DOWN BY THE SOIL OR BY PLANTS?

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The question that forms the title of this paper is important in connection with the fairly widespread yet one-sided idea that the similar action of superphosphate and ground phosphorite on acid soils is due solely to the effect of the acidity of the soil in breaking down the fertilizer particles. Only in the case of such crops as lupine, buckwheat and certain others is it accepted that they are capable of breaking down phosphorite by themselves.

All the experimental and theoretical evidence collected during the last 35 years convinces us that even in the case of phosphorite application under grain crops the soil must be regarded primarily as a medium which determines the activity of the plants in breaking down phosphorite rather than as an independent agent in this. Let us examine the reasons for the erroneous ideas behind this exaggeration of the capacity of soils to break down phosphorite.

First, there are errors in regard to method. It is accepted practice to estimate the decomposition action of the soil on phosphorite from the difference between the amounts of phosphorus extracted from unfertilized soils and the amounts extracted from soils which have been treated with phosphorite. More phosphorus is, as a rule, extracted from the latter, the amount being higher in the case of acid soils than in the case of neutral and greater than in alkaline soils. On this basis it has been inferred that acid soils exert a stronger decomposing action of phosphorite and that this is why phosphorus availability to plants is higher in such soils.

A connection was later established between the "decomposing" action of soils on phosphorite on the one hand and the values for the capacity of their adsorption complex and degree of its base saturation, on the other. The decomposing action of leached chernozems on phosphorite is explained by their base unsaturation.

It should not be forgotten, however, that at the moment when the soil extracts are prepared the acidity of these extracts is capable of exerting a decomposing action on phosphorite particles. This can be readily seen if one takes the same quantity of phosphorite as was added into the soil and treats it with the same extract but without the soil. Some authors have made such tests but have not attracted attention, obviously because this method of trying to detect the phosphorus which passes from the phosphorite into the soil solution has not been successful Experiments by Doyarenko (14) and others, for example, have shown that phosphorite in podzolic soil is well assimilated by millet, although neither a water nor an acetic acid extrac has revealed any positive influence of the soil o phosphorus solubility. Extracts from phosphorite alone contained more phosphorus than extracts from phosphorite in the presence of soil. The soil therefore did not enhance but reduced the decomposing action of the original extract solution on the phosphorite particles.

Further research for the purpose of discovering the capacity of different soils to break down phosphorite usually fails to take into account the direct action of the extract on the phosphorite. These tests left it an open question whether the change in the amount of phosphorus extracted should be attributed to differences in the capacities of soils to dissolve phosphorite or to differences in their capacity to inhibit the dissolving action of the extracts. Kupreyenok (17) and others succeeding in fairly clearly establishing that the decomposing action of the extract on phosphorus was enhanced when the phosphorite was composted with peat only in tests with acid peat but not in tests with soil.

Even acid soils, however, cannot be compared with acid peat in regard to free acid content. Still less is there any basis whatsoever for attributing the relatively high action of phosphorite on such soils solely to their decomposing and particularly their dissolving action. It would be more correct to regard acid soils as a medium favorable to the decomposing action of plants on phosphorite particles. Such soils contain little calcium and therefore promote higher activity in the decomposing action of plants on phosphorite particles. It is no accident that the effectiveness of phosphorite has been enhanced by isolating part of the phosphorite-containing roots of grain crops from the main body of a calcium-rich nutrient medium, and that this improvement has usually been greater in inverse ratio to the amount of calcium salts isolated with the phosphorite (22).

Table 1 shows the results of some of our research on leached chernozems. In these experiments soil-free phosphorite extracts were used as the control. Side by side with the phosphorite

Table 1

Influence of leached chernozem on solubility of P_2O_5 in phosphorite and superphosphate. Amount of P_2O_5 extracted from 1 g of phosphate, mg

Phosphate	Water extract			Carbonic acid extracts		
	From phosphates		After composting with soil for 12 days	From phosphates		After composting for 42 days
	Without soil	Mixed with soil		Without soil	Mixed with soil	
Phosphorite	4,1	0,5	0,8	28	20	25
Superphosphate	166	72	15	814	99	48

Note: The figures for the mixtures and composts have been arrived at by deducting P_2O_5 extracted from the same soil.

Note: Comma represents decimal point.

eriments super-phosphate was also texted.
ter and carbon dioxide extracts were used at
oil-extract ratio of 1:50. In the former
e, shaking was continued for five minutes,
he latter for 60 minutes (bubbling through
h CO_2 from a cylinder).

As Table 1 shows, the soil reduced the dis-
ving action of the extracts on the phosphorite
at the same time strongly bonded the P_2O_5
he superphosphate. As a result there was a
rked convergence in the solubility of these
sphates, particularly in regard to carbonic
d-soluble P_2O_5. This convergence was par-
ılarly abrupt in the podzolic soil, where
re was a rapid transition in favor of the
sphorite. Namely, when the phosphates
e composted with podzolic soil (wetted up to
of capillary moisture capacity) despite the
n amount, 109 mg P_2O_5 was extracted from
phosphorite and 75 mg from the super-
sphate from 1 kg of soil (after deduction of
g P_2O_5 extracted from the non-fertilized
) with a weakly acid extract of 0.005 N HCl
5 agitated for 5 minutes) only one month af-
composting had started. This period
ved sufficient in the case of podzolic soil to
erse the better solubility of the superphos-
te in comparison with the phosphorite.
re is, of course, no basis for attributing
advantage to the decomposing action of the
on the phosphorite. If we assume that the
did not break down the phosphorite com-
ely in one month (an assumption which is
r the truth) the retrogradation of the super-
sphate is in itself sufficient to account for
considerable convergence of these phos-
tes in regard to availability.

Ve shall not cite here all the values from
lysis which would refute the contention that
equalizing of the action of these phosphates
ue to the capacity of phosphorite to be bro-
down by the soil. We would only point out
determination of the P_2O_5 group composi-
by Chirikov's method in soils (even leached
rnozems) which have received superphos-
e and phosphorite has shown that in the
t case hydrochloric acid-soluble forms of
$_5$ predominate (Fe and Al phosphates) where-
n the latter case acetic acid-soluble forms
lominate (Ca phosphates). The phosphorite
particles accordingly retain their calcium phosphate form, whereas a considerable part of the super-phosphate P_2O_5 is bonded in less readily soluble sesquioxide compounds. In podzolic soils this occurs more rapidly and in a more pronounced form.

As long ago as 1928, we began to think that the decomposing action of plants on phosphorite was stronger than that of the soil and advanced the following views: a) there are no calcium phosphates which would be unavailable to plants if all the factors preventing the dissociating action of the roots were eliminated; b) if we compare the action of soil on calcium phosphate with the action of pure solvents (for example, water, citric acid and others) we shall find that all soils lower the phosphate solubility, their action being in direct ratio to the calcium content in the soils and in inverse ratio to the H-ion content; c) there is no direct interaction between the plants and the phosphates. This action is brought about only by means of a solution, which even if it is only in the form of a thin film, must separate the reacting phases from each other (despite the contention later put forward by Jenny and Overstreet [25], but subsequently refuted, to the effect that there is a direct "jump" of ions from the soil into the plant roots); and d) the properties of the solid part of the soil do not exert a direct influence on the utilization of phosphates by plants, since the interaction between plants and phosphates is determined by the components of the soil solution. The solid phase is important in so far as these components are determined by its properties.

All these contentions support the view which was later formulated more clearly, that the soil is primarily a medium which determines the interaction of the plants with the phosphorite rather than a factor operating directly in its decomposition (7).

The first to establish a connection between the ability of various plants to break down phosphorite and to absorb calcium was Chirikov (22). Developing his views, we have succeeded in showing (5) that the calcium concentration in the root zone of the plants, and consequently their capacity to break down the phosphorites, is determined by the comparative rate of calcium and water intake by the plants. Naturally, if the plants take in calcium and water at the same rate (in the ratio in which they occur in the soil solution) the calcium concentration in the basic solution will not alter. In order for it to be reduced the plants must take up calcium faster than water. The relationship between the decomposing action of the plants and these values is expressed by the formula

$$X = \frac{E \cdot Ca}{Ca_1 \cdot L}$$

where X is the force of the decomposing action of the roots, E the yield in grams, Ca the calcium content per gram of yield in mg, Ca_1 the calcium content in mg per liter of nutrient solution and L the number of liters of water taken up by the plant.

In conformity with the foregoing formula millet and corn, which have a lower transpiration coefficient than grain crops utilize phosphorite better than the latter. Dobrunov (12), on the basis of his research with different varieties of hemp, also came to the conclusion that "of the indices suggested for the degree of phosphorite assimilation by plants, Buktevich's is the one that most favors an active degree of assimilation of this form of phosphoric acid."

Askinazi (1), proceeding from the one-sided explanation that the action of phosphorite is due to the action of soil acidity in breaking it down, without taking into account other conditions determining its effectiveness, draws the inaccurate inference that liming soils is incompatible with subsequent application of phosphorite to them. Here he ignores the enhanced capacity of the plants themselves to use phosphorite as a result of the overall beneficial effect of liming on the soils from the consequent elimination of the harmful effect of aluminium on them, the increase in calcium and often magnesium availability, the improvement of nitrogen supply from an increased nutrification, the general improvement in the tilled condition of the soils and so forth. A one-sided approach to the question makes it impossible to explain why the leached chernozems, although they possess less acidity, are usually a good medium for phosphorite utilization by plants.

If the cultivation condition of podzolic soils could be improved by liming until it reached the standard of leached chernozems with a saline extract pH of 5-6, the effectiveness of fertilizing such soils with phosphorite would be enhanced, not reduced. It should not be forgotten that the purpose of liming is to get rid of harmful, but not all acidity of the soil.

Pryanishnikov (20), summarizing experiments on soil liming, wrote that "at a salt extract pH of less than 4.5, the soil greatly needs liming; at a pH between 4.5 and 5.5, the need for liming is less; at a pH of more than 5.5 liming is not necessary at all." According to the VIUA (All-Union Institute of Fertilizers and Soil Science) figures (Kedrov-Zikhman and Yarusov) soils with a salt extract pH of 5.0-5.5 can be classed as only slightly needing liming. There is surely no basis at all, however, for maintaining that such soils are not responsive to phosphorite. The speculative inference that liming is completely incompatible with phosphoriting unless the phosphorite is applied before the lime does not agree with the facts.

If both operations are planned the phosphorit should undoubtedly be applied before the lime, since it is impossible to omit the mobilizing action of high soil acidity on it; but there is no ne to conclude from this that ground phosphorite should in general not be applied after lime.

Askinazi (1), referring to the hypothesis that there are two solubility peaks for highly basic calcium phosphates ($Ca_3(PO_4)_2$ and phosphorite), one of which is in the acid reaction region (pH about 5) and the other in the alkaline reaction region (pH about 7.5-8.0), very properly objects to the combination of phosphoriting with liming before the second solubility optimum has been reached. It is a long time, however, since any one has suggested such excessive liming as to reach the alkaline reaction.

Nor can we ignore recently discovered methods which have extended the possibility of using phosphorite in a highly effective way, such as the double-layer application of phosphates (super-phosphate under the seeds, phosphorite deeper), focal application of phosphorite in a physiologically acid salt mixture, activation of the mineral acids with small amounts of fertilizer and so forth. We note that the improvement of phosphorite availability by isolating the phosphorite in the nutrient medium together with KCl has been observed in tests by Samoylov and Shulov (23), Chirikov (22), and Golubev (10).

Even if the Chirikov factor (the $CaO:P_2O_5$ ratio in plant ash) did not justify the importance attributed to it by Chirikov as an index of the comparative capacity of various plants to utilize phosphorite, his contention that this capacity increases in proportion to the energy of their calcium adsorption has been widely accepted. If it were the soil rather than the plants which broke down phosphorite, we should detect no difference between one plant and another in this respect. In fact, however, we know that there is a fairly distinct difference, for example, between wheat and lupine, not only as between sandy and soil crops but also in field experiment

Lastly, percolation tests made by Kossovich (15), and Chirikov (22) have shown that solutions passed even through an acid soil fertilized with phosphorite did not supply the plants with phosphorus, whereas the presence in the same soil of a contact between the plant roots and phosphorite particles made it possible to obtain normal yields. In regard to the acidulation and solution of phosphorite under the influence of the nitrification process, Lebedyantsev's experiments did not in reality reveal any such action. Moreover, Lebedyantsev (18) concluded that "nitrates and available phosphorus are antagonists in the soil as a result of the activity of the microorganisms causing their biological fixation..."

In that case, how can we explain the positive influence of nitrates on phosphorite assimilabilit without considering the improvement of the nitrogen supply to the plants? As our investigations have shown (4), the alkaline buffering of the soil solution (its titratable alkalinity) falls as rification increases. As a result, the acity of the plants to acidulate the solution he zone of interaction between their roots the phosphorite particles increases, and sequently the solubility and assimilability of phosphorite also increase. At first sight, eems paradoxical that the phosphorite as- ilability increases at the same time as the gration of its phosphorus into the soil solu- n decreases; but when there is an interaction tact between the phosphorite and the plant ts, fixation of the phosphorite phosphorus by croorganisms cannot take place.

f the soil acidity (of chemical or biological gin) were to exert so strong a decomposing ion on phosphorite as is frequently believed, can one explain a phenomenon detected by ashev (2) in long-term field experiments: e residual effect of phosphorite alternately es up and dies down, showing on the whole endency to weakening, usually over a long iod of years." This indicates merely that in erent years, as one would expect, there are erent conditions developing the plants' ity to extract phosphorus from the phosphor- particles. Again, how shall we explain the nomenon noted by Askinazi (1): "In a num- of cases, phosphorite applied to the soil d soils. — V. B.) continues to have an ef- for 30 years or more, whereas the action uperphosphate fades out much more quickly." cid soils really possessed an active dis- ing action, we should have to assume that 0 years after the phosphorite had been bro- down by the soil there would be just the e fading out of its action as in the case of erphosphate. We know, however, that not after 10 years but even after much longer iods phosphorite, unlike superphosphate, is only just as effective but in many cases even e so.

Vhat is the explanation? The natural process vhich phosphorite is converted into a more lable state is obviously not accompanied by entry of its phosphorus into solution and the tion of this phosphorus by the soils in the n of compounds not readily available to ts. Over a long period of years the phos- rite acts as a highly localized source of sphorus supply to the plants.

ccording to accepted ideas in fertilizer nology, "raw" phosphates (phosphorite, ite) must be broken down as completely as sible in order that their phosphorus may be verted into an available state; i.e., the opti- n output of water-soluble P_2O_5 per unit of re- t used must be obtained. But how far is a high degree of decomposition really essary? Our experiments with plants (6, 7) ved that there is an optimum phosphate bility, and also an optimum degree of phos- rite decomposition, and that above these ls further expenditure of reagents does not ease the yield. On the other hand, of course, tilization factor of the reagents, which we sured not by the output of soluble P_2O_5 per of reagent but by the yield increment cal- ted per unit of reagent, falls steeply.

he problem of phosphate solubility and lability is fairly complicated. This applies icularly to our amorphous (non-crystalline) phosphorites, which proved very responsive to treatment with even very small amounts of reagent. After studying the interaction of the phosphates obtained by this method with the plants we came to the conclusion that there was no necessity to substitute the decomposing action of chemical reagents for the action of the plant roots.

The fact that phosphorite is more intensively broken down by plants than by soils makes it possible to produce phosphates which can be taken up by plants to a greater extent than they would be adsorbed by the soils.

The phosphorus which plants extract from phosphate particles as a result of contact interaction between their roots and these particles belongs to the plants, whereas the water-soluble phosphates introduced into the soil combine with it to a greater extent than with the plants unless special measures are applied (granulating the superphosphate, placement application and so forth). Recent experiments with labelled phosphates have confirmed that it is most important for the superphosphate granules to be very near the roots of young plants.

If the soil, with its better natural capacity for adsorbing phosphoric acid ions, broke down phosphates more quickly than plants do, the problem of producing phosphates available in greater quantities by plants than by soil would be an impossible one. Once one understands the great importance of this problem one is no longer inclined either to exaggerate the decomposing action of soils on phosphorite or to underestimate the importance of superphosphate retrogradation in soils. "Ground phosphorite, like superphosphate," writes Chirikov (21), "is converted in the soil into phosphate forms typical of the soil in question and therefore superphosphate must suffer retrogradation and not produce residual effects in the same way as phosphorite fertilizer." There is no basis, however, for doubting the relatively weak residual effect of superphosphate. It does not in fact produce the same residual effect as ground phosphorite, nor should it; this in itself refutes the notion that they are converted into identical "phosphate forms typical of the soil in question." Moreover, the difference between phosphorite and superphosphate, as prolonged tests have shown, increases with time in favor of phosphorite. This has been confirmed with particular clarity from the findings of the Western Experiment Station (2).

It is equally impossible to see any sufficient reason for the attempt to minimize the role of the superphosphate P_2O_5 retrogradation process. Chirikov (21), discussing this question, adduces the example of enhanced superphosphate residual effect in cases where the plants were well supplied with nitrogen. Yet this adequate supply of nitrogen did not raise the superphosphate residual effect above the level of the phosphorite residual effect. To give a realistic evaluation of the residual effect of water soluble P_2O_5 one must take into account that its production entails the consumption of about one ton of industrial sulfuric acid per ton of apatite, and that the latter has to be transported thousands of kilometers to the superphosphate works, whereas locally produced ground phosphorite produces, in its residual action, yield increments no lower and as a rule much higher than superphosphate. As Chirikov points out at the end of his book (21), "the duration of the residual effect of superphosphate on podzolic soils is of the order of 3-4 years; that of Thomas slag, depending on the amount used, does not exceed 10-12 years; the residual effect of phosphorite, however, in amounts of 90 kg P_2O_5 or more has been found to last 16 years after application."

It is often said that contact between lime and phosphorite is undesirable, although direct interaction between them is unlikely if their particles are distributed over 3 million kg of plowed layer (provided the particles are not mixed); yet surely lime entering into the composition of the phosphorite itself (up to 10% of its weight) and really in close direct contact with the phosphate substance of the phosphorite will play a far greater part. The process of phosphorite mobilization is of first importance in breaking down this lime, increasing the availability of its phosphorus, as we pointed out in greater detail in a separate paper (7).

The positive value of the paper by Askinazi (1), quoted previously, is that he has raised in controversial form a number of questions relating to the use of ground phosphorite. This will cause these questions to be cleared up more quickly.

He has in fact, however, left out the middle link in the chain soil-plant-fertilizer (Pryanishnikov's triangle). Although he recognizes that "the plant itself can be a powerful factor in solubility," he nowhere indicates the conditions under which plants can play such a role. Moreover, while objecting to the "exaggeration" of the role of plants, he throws doubt on the credibility of cases where the effectiveness of phosphorite has been accounted for by the action of the plants on it and could not be explained by the action of the soil acidity on it.

In conclusion, we may say that there is not yet a sufficiently clear understanding, in the agricultural chemical literature, of the comparative importance for phosphorite assimilability of the processes of their interaction with soils on the one hand and with plants on the other, and that further joint efforts are required on the part of physiologists, agricultural chemists and soil scientists to work out a single correct point of view on these important questions. Meanwhile, after examining the available information on these matters, we believe that the following adequately proved propositions can be adduced in the conclusions suggested below.

Conclusions

1. Such soil properties as adsorption capacity and degree of base unsaturation are the basis for classifying soils according to the degree of their responsiveness to phosphorization, in view of the fact that these properties determine their direct decomposing action on phosphorite. The role of these properties, however, must be interpreted differently, since these properties of soils again largely determine the capacity of plants to break down and use phosphorite. This, too, is the main respect in which different soils respond differently to application of phosphorit

2. The application of superphosphate and phosphorite to the soil is accompanied by opposite processes: superphosphate radically tur into less available forms, after which a certair equilibrium is established between the phosphat and the soil; the conversion of phosphorite in th soil into a more easily available state is a muc slower process, measured in years and even decades.

The similar action of the phosphates indicat is determined by the retrogradation of superphosphate, not by the decomposing action of soi acidity on phosphorite, as has usually been supposed.

3. The explanation for the conversion of phosphorite in soils into a more easily availabl state should not be over-simplified as due to th entry of its phosphorus into the soil solutions (research on this phosphorus has not often been successful). It is more accurate to regard this process as a mobilization, the essence of which is to be found primarily in the partial decompos tion of the $CaCO_3$ contained in the phosphorite, with the result that the $CaCO:P_2O_5$ ratio in the phosphorite particles alters in favor of the P_2O_5. This process makes it easier for the pla to extract phosphorus from the phosphorite particles.

4. It is of interest to discover more about the conditions of the medium, which, apart fron soil acidity, has in many cases no less importance in bringing out the action of phosphorite, and it would also be worth working out methods of activating phosphorite which would enhance its availability to plants and would considerably extend the farming and geographical conditions under which phosphorite could be used, while at the same time enhancing its effectiveness in limed soils as well.

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SOIL SILVICULTURAL ZONING OF THE BRYANSK OBLAST'

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A considerable part of the Bryansk Oblast'—at present, 23.7% of its area—is covered with forest. Forestry plays an important part in the economy of the Oblast'. The water and soil conservation, water regulation, and climate influence of the forests are of particular importance.

During the Second World War and the immediate post-war years these forests suffered a great deal of destruction. The plan for forestry development during the next few years aims at making the Bryansk forests even more valuable and productive than before. The measures to be taken for this purpose cover a wide range: reducing the proportion of softwoods, introducing specialized forestry for the different forest rayons, enriching the stands with new industrially valuable plants, draining waterlogged areas, introducing soil-improving undergrowth in poor soils, afforestation of areas where there are no forests, and so forth.

The natural conditions of the Bryansk Oblast' are generally favorable to forest growth but are not uniformly so in all parts. If the region's forestry is to be organized properly the forest management practices will have to be differentiated according to the natural conditions (soil and subsoil, hydrological and, to some extent, climatic).

The territory is situated at the junction of three landscape-geographical zones. Its southeastern part is the northeastern borderland of the Orlovskaya-Khar'kov forest steppe subrayon; its northern part is the southern extremity of the central podzolic rayon; its western part is the eastern borderland of the Belorussian Poles'ye. Each of these parts has characteristic features peculiar to the particular zone. This is reflected in the differences in relief, soil, the composition and properties of surface soil-forming parent material, vegetation and other natural conditions. The soils vary. All the transitional stages from sod—strongly podzolic sandy soils to podzolized and leached chernozems are to be found. The geological structure includes deposits of varying composition. There is a wide variety of soil-forming parent material (water-glacial and old alluvial sands, sandy loams, moraine, loess-like deposits, sedimentary parent rocks of the Cretaceous period). Different parts of the Bryansk forest area differ in composition and distribution of the main tree species as well as in their growth characteristics. In the northern part, for example, spruces predominate; in the eastern part the main forest-forming trees are pine, oak and those derived from stands of these trees; the southwestern part is a hornbeam-pine-broadleaf zone with islands of spruce. Conditions, then, favor the growth of different groups of trees, according to the soils and soil-forming parent material which predominate in the different zones of the Oblast'.

In view of the variety of soils, climatic and other conditions, we (A. Ya. Antykov and P. I. Chesnokov) have distinguished five more or less independent forest areas occupied by forests.

The purpose of forest rayons is to achieve a more accurate solution of the problems of reproducing high quality wood and implementing other forestry management practices, depending on the natural, primarily soil and subsoil conditions, of the Oblast'. The forest rayons are described below.

Rayon I. Northern mixed forest zone of southern borderlands of the central podzolic zone with predominance of sod-podzolic sandy loam and sandy soils on fluvioglacial deposits. This rayon includes the Kletnyanskiy forest, the greater part of the Zhukovskiy forest (except for the Rzhanitskiy and Trostyanskiy forestries), the Dyat'kovskiy forest, the Batagovskiy forest of the Bezhitskiy forest, and the Zhurinichskoye and Zheltokovskoye forest of the Karachevskiy forest.

The total area of the State forests is 27.4%. The rayon is distinguished from others by having a somewhat severer climate. The mean annual temperature varies between +4.7°C and +5.4°C; the mean temperature from May 1 to September 1 is between +16° C and +17° C. Total annual precipitation is 570-610 mm.

Geomorphologically the rayon is a high lowland, somewhat broken up by a network of ravines and gullies. The Seshchinskaya glacial dislocation occurs in the western part of the rayon. In this part of the Oblast' the Dubrovskiy Roslavskiy elevated junction stands out; here the absolute height above sea-level varies between 200 and 292 m. Along the Desna extends a sizeable plain, occupied by old alluvial sands and sandy loams. Sod-moderately and strongly

dzolic sandy loam and sandy soils predomin-
e, formed on fluvioglacial deposits over Cre-
ceous sea parent materials (marl, eluvial
oka clay and others) in the eastern part and
oraine in the western part. Water-logged
aty- and peaty podzolic soils are also found
this rayon. The distinctive feature of the
ee stands is that they are of a mixed kind:
nifers occupy 32% (including spruces, 7%),
k 3%,birch, aspen and alder 65%. Spruce is
mmon in the zonal conditions, where it is the
edominant species or admixture. Deciduous
antations, which are derivatives of the coni-
rs, occupy the greater part of the territory.
ne oak is also found over small areas. All
is justifies the accepted name of "mixed for-
t zone." The soils of this rayon are favor-
le to growing highly productive plantations of
ne and spruce with some new species, for
ample, the European larch. The oak can be
own in the bottom lands.

The aims of forest management in this
yon are to assist natural regrowth, reduce the
ocess of succession, and improve the quality
regrowth. Since mixed small-leaf young
ees and medium aged stands of spruce forest
th spruce regrowth are common in this
rthern mixed forest, improvement cutting is
great importance here.

II. Pine forests rayon of old Desnitskiy low-
nd terraces with predominance of sandy sod-
dzolic soils formed on old alluvial deposits
derlain by rocks. This zone includes the
ukovskiy forest (southern forests of Rzhanit-
iy and Trostyanskiy), the Bezhitskiy farm
art from the Batagovskiy forest and the
rachevskiy, Suzemskiy, and Trubchevskiy
rests. The total area of the State forest area
41.6%. The ratio of forest to total area is
.5%. The forest area of this rayon takes the
rm of a wide belt (up to 30 km) along the left
nk of the Cis-Desna lowlands. In this part of
Oblast' there are very pronounced recent
d old terraces of the Desna River formed on
l alluvial and occasionally sandy loam deposits
er Cretaceous moraine rocks (quartz-
uconitic sands with and without phosphorites,
athered and leached opoka clays, chalk,
rl). In places, the primary rocks emerge at
surface and become soil-forming parent
terial. Over a considerable area of the for-
rayon, these rocks are covered with old
uvial and alluvial deposits of varying thick-
ss (from 1-2 m). In some places these de-
sits are windblown and high dunes have
med out of them. In these cases they are 5-
h thick.

Sod-slightly and moderately podzolic sands
l sandy loams on old alluvial deposits are
nmon in this rayon. These usually coincide
h the fourth and fifth terraces. In the water-
ds there are patches of clay loams, humus-
bonate soils rich in nutrients, humus-car-
ate leached soils, chernozem-like soils, and
o strongly and moderately podzolic soils on
thered and leached opoka clay. On the
pes, slightly and moderately podzolic soils
quartz-glauconite sands with phosphorites
common and in parts of the lowland near
terrace, soils of a bog subgroup (clay—
y and others). Owing to the predominance
oarse textured soils, pines cover 53% of the total forest area. Oak stands are common in the bottom lands (9%). Soft-leaved trees make up 36%; the spruce is found in the river valleys and covers 2% of the total area. In the pine plantations subsoils of the pine type of forest take up 46.1% of the total area, those of the mixed pine type 49.6% and those of the mixed spruce type, 4.5%. In regard to moisture the pine forests may be classified as dry and very dry (2.2% of total area), slightly moist pine plantations (67.1%), humid (26.5%), and wet (4.2%). Poorly productive types of forest (all except the new plantations) occupy 32.9% of the area. The average site quality of the pine plantations is 1.6.

Owing to the predominance of coarse-textured soils in the rayon, the main tree species found here is the pine. The favorable climatic conditions, however, and the proximity of rich subsoils make it possible to extend the forest areas, particularly in the river bottom lands, with oak, ash and basswood. As there are fairly large waterlogged areas, particularly in the Navlinskiy, Trubchevskiy, and Bryansk forests, a combination of meliorative measures is required. Silviculture is most intensive in rayon II, so regeneration here must be both natural and to a large extent artificial (by cultivation). In the dry pine and very dry types of forest the introduction of undergrowth (broom) can have a healthy effect on the soil, birch can be used as a long-term admixture and speckled alder, mountain ash, and broom among the undergrowth trees in the sandy soils.

III. Novozybskiy-Klintsovskiy pine forest rayon on sod-podzolic sands and sandy loams of Poles'ye lowlands over moraine. This rayon includes the Klintsovskiy and Novozybskiy forests. Forests cover 10.3% of the total area, coinciding mainly with the old river terraces of Iput' and Snof Rivers. The rayon is situated in the southwestern part of the Oblast'. The climate of the zone is temperate; in summer, dry months are frequent. The mean annual air temperature at Novozybkov is 5.2°C, at Unecha 5.3°C and at Zlynka 5.9°C. Mean annual precipitation is 559 mm at Novozybkov, and 599 mm at Unecha. The relief is slightly eroded and mainly flat, but slightly undulating in places where the ground rises to 150-180 m. The commonest soils in this zone are sod-slightly podzolic, and less frequently moderately podzolic sands and sandy loams over moraine or sand and sandy loam. The characteristic features of these soils are absolute structurelessness, high aeration, low moisture capacity (22%-28%), high water permeability, poor capillary rise capacity and an exceptionally low content in humus (0.4%-1%) and nutrients. In the small, flat hollows (saucers) podzolic gleyey soils predominate. Conifers and deciduous trees make up the forests. Pine plantations cover 62% of the forest area (site quality III), soft-leaved trees 31%, oak 4%, and spruce 3%; spruce is not found in the zonal conditions but only in the river valleys.

The distinguishing feature of the rayon is that the northeastern boundary of the hornbeam area passes through it. Hornbeam plantations of high site quality are found over small areas both in the form of admixtures and as the predominant forest vegetation. The forest soil and ground waters and hydrological conditions in this zone are severer than in rayon II. This can be seen from the fact that the pine forest occupy 68.6% of the total area, the mixed pine 29% and the mixed spruce 2.2%. Of the total forest area 13.8% is made up of dry and very dry types of forest, 55.7% slightly moist, 34.9% moist, and 5.6% of wet. Less productive types of forest take up 54.8% of the rayon against 32.9% in the Desna lowland rayon. Rayon III has a low stand density (10.9%); in places where the forests have suffered much destruction, small islands of forest are found. It will be necessary to increase the forest area by using other lands, mainly the loose-sandy-soil wastelands which are unsuitable for farming, and the marginal lands and unproductive pastures. In view of the high soil conservation value of the rayon's pine and pine-type of forests it will be advisable to rely primarily on artificial reforestation. Measures to promote reforestation based on the natural seeding of areas in pine forests situated on a relief made up of knolls and hills are not very effective.

A great deal of successful work has been done by the Novozybkov State Forestry in recent years in creating forests on sandy soil (within the natural boundaries of the "Zayputskiy subsoil," Lyudkovskiy sands, and elsewhere). Although climatic conditions favor many tree varieties including the oak, hornbeam and others, the pine must be regarded as the main tree for silvicultural purposes in this zone.

IV. Eastern Brasovskiy-Sevskiy broadleaf-pine forest rayon of Orlovskaya-Khar'kov forest steppe borderlands on grey forest and sod-podzolic soils. The rayon lies in the eastern part of the Oblast' and includes the Brasovskiy and Sevskiy forest which make up 5.6% of the total area. The forest density of the rayon is 17.5%. The forests coincide with the relatively low stands gravitating down to the Nerussa and Ivota Rivers and others. The area surrounding the forest areas and rising to the western spurs of the Central Russian elevation is distinguished by extensive undulations and deep erosion gullies occurring irregularly in certain parts. In the Sevskiy rayon, for example, these erosion river gorges are 85 m deep. A similar pattern is found in the areas between the Navel' and Nerussa Rivers, and the Nerussa and Sev Rivers. The zonal climate has some continental features (prolonged periods without rain in spring). The mean air temperature in January is -8.8°C, in July +18.4°C. Total annual precipitation is 560-580 mm. Dry types of forest make up 11.3% of the total area, moist and damp types 16.1%. The forests coincide with sandy loam sod-podzolic soils on old alluvial rocks and light-grey forest soils. Humus-peaty-gleyey soils and peat deposits are widespread in the bottom-lands.

The forest vegetation is 30% pine, 33% oak, 14% birch, 20% aspen, 3% alder, so highly productive oak stands and the derivatives of oak plantations predominate. Pine forests with birches come second and also make up a high percentage of the total.

The hedge maple and European Evonymus, which are typical of the forest steppe, are characteristic features of this rayon. The favorable temperature conditions in the growing period make it possible to grow mainly the oak, which can spread both in the river bottom-lands and in the watersheds. As the soil-forming parent material is rich in nutrient elements the rayon can be used to develop basswood, maple, elm, and other trees. Nut trees and fruit berry varieties, which can be used in plantations and, as required, in ravines and on steep riverbank slopes, are promising subjects for the fertile grey forest soils of this rayon. Soil conditions here are favorable for quick-growing trees, particularly poplars. Windbreak plantations must also be developed.

V. Central broadleaf rayon of the right bank of the Desna and Sudosta with considerable erosion dissection and prevalence of sod-podzolic coarse clay loam and sandy loam soils. This rayon includes the Mglinskiy, Pochepskiy and Unecha forests, with 15.1% of the total area under forest. Stand density is 20.2%. The central part of the Oblast' is an elevated broadly undulating plain on the right bank of the rivers, intersected by short but deep gullies and ravines and by brooks and small rivers. The average density of the erosion dissection is 0.7-0.9 km per km². Soils are transported sod-podzolic on loess-like clay loams and light grey fine silts, and also sandy loams and sands in the river terraces. Compared with the fourth, eastern forest rayon, the fifth rayon is distinguished by having a more moderate climate (soil moisture coefficient of more than 14.6%) and some difference in the origin and composition of the soil-forming and bedrocks—traces of glacial survivals in the form of moraine (Unecha forest), occasional outcrops of weathered and leached opaka clay and marl (Pochepskiy forest)

The forests in this rayon occupy the often very moist level surfaces. Pine accounts for 28 of the forest area, birch for 20%, oak for 19%, aspen for 28%, alder for 1%, and spruce for 4%. The last-named species is found in the river and brook valleys. The pines and birch forests grow mainly in sandy and sandy loam soils, the oak and aspen in clay loams. Under the conditions prevailing in the rayon, the pine forests and their derivatives (birch forest) occupy 48% of the total area, or much the same as the oak forests and their derivatives (aspen), which make up 47% of the total area.

In order to enhance the value and improve the productivity of the forests in this rayon, it is of some importance to drain the many parts which are water-logged, mainly with stagnant waters, in the soils where the leached opaka clay is bedded near the surface. Silvicultural work in the rayon must be directed towards restoring the oak plantations in places where they form highly productive timber stands. Forestation for soil-conservation and windbreak purposes must be extensively developed in this central zone (in the ravine and gully formations and on the collective and state farms).

In all the rayons enumerated previously it is essential to take steps to reduce or completely stop the processes of forest-forming tree-stand succession and of the formation of valueless small-leaf plantations.

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HIBITION OF THE ACTIVITY OF SOIL MALTASE

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The inhibition of the activity of certain soil ymes has already been studied. It has been wn, for example, that prussic acid (26), posium cyanide, sodium nitrite (28, 31), SO_4, 4, Cl, and NO_3 anions (1) greatly reduce the ivity of catalase in the soil whereas meric chloride scarcely affects this enzyme (29). l urease is inhibited by mercuric chloride, psin, hydroquinone, and pyrocatechin (12). rcuric chloride is the best inhibitor of soil ylase (17). n-Toluidine, aniline, mercuric oride, formaldehyde, and lead acetate init the activity of soil saccharase; methye blue and streptomycin do not effect this yme (21, 24). Comparison of the action of 'oluidine, aniline, and mercuric chloride soil saccharase and also on saccharase roduced into the soil in the form of yeast l and yeast autolysate suspension showed , 22, 24) that saccharase is very resistant he inhibiting action of these substances; the l exerts a protective action on the sacchar, this action being more pronounced in ard to natural saccharase than in the case of st saccharase added into the soil.

The purpose of this paper is to study the vity of soil maltase and its modification er the influence of various inhibiting subices. Maltase is at once a hydrolyzing and nthesizing enzyme, that is an α-glucose-isferring enzyme which transfers the α-glue residue from the donors (for example, tose) not only into water (hydrolyzing reac) but also to other acceptors (saccharids) reby synthesizing certain oligosaccharids. s phenomenon has been observed in regard ie maltase of molds (27, 11), bacteria (9, and yeast (19). During the action of maltase on maltose certain oligosaccharids formed in addition to the glucoses (2, 25).

Maltase preparations are inhibited by heavy al ions (13). Streptomycin sulfate in conration exceeding 0.1% inhibits the synthesizaction of the maltase of an acellular extract *. coli* (10).

Materials and Methods

he soil under study was a degraded cherno- (humus content 3.86%, total nitrogen 0.232%, .8). Maltase was first added into the soil ole at the rate of 1 g per 100 g of air-dry soil and incubated at constant moisture and room temperature for 120 days to increase the maltase content in the soil. We based this procedure on figures for the influence of a specific substrate on the production of the corresponding enzyme in the soil (30, 2, 20, 3, 22, 24).

Four treatments for inhibiting the activity of soil maltase were set up: A — without inhibitor; B — with dihydrostreptomycin; C — with $AgNO_3$; D — with $HgCl_2$. Each treatment was performed on three samples: I — a soil-free (enzyme-free) substrate as the control sample; II — a sample with soil without maltose; III — a sample with soil and with maltose. The inhibitors studied were used in solutions of the following concentration: $AgNO_3$ — 0.2%; $HgCl_2$ — 0.2%; sulfate of dihydrostreptomycin — 20%. The substrate was a 20% solution of maltose. The reaction mixture of samples II and III in treatments B, C, and D were made up of 2 g of air-dry soil plus 0.5 ml of toluol plus 5 ml of inhibitor solution plus 5 ml of substrate solution. In treatment A, 5 ml of water were used instead of the inhibitor solution. The reaction mixture of sample I was identical with the mixture of the corresponding samples II and III except that sample I contained no soil.

Since dihydrostreptomycin is a compound of oligosaccharid type, we suggested that it could undergo enzymatic hydrolysis. We therefore prepared a control sample consisting of 2 g of soil plus 0.7 ml of toluol plus 5 ml of dihydrostreptomycin solution plus 5 ml of water (the latter was used instead of the maltose solution).

The reaction mixtures were incubated in a thermostat at 37° C. The samples were taken from them at fixed intervals (2.1 mm³ each time) for sugar analysis by descending chromatography on paper (Whatman 1). The solvents were n-propanol-ethyl acetate-water (6:1:3) (2) and n-butanol-ethanol-water-ammonium hydroxide (4:1:4.9:0.1) (10). The solvent was passed through for 14 hours at room temperature. Developers were $AgNO_3$ (32) and diphenylamine-aniline-orthophosphoric acid (14).

Results

Figure 1 shows the chromatograms obtained after 21 days incubation of the reaction mixtures. In sample I the spots of maltose and isomaltose

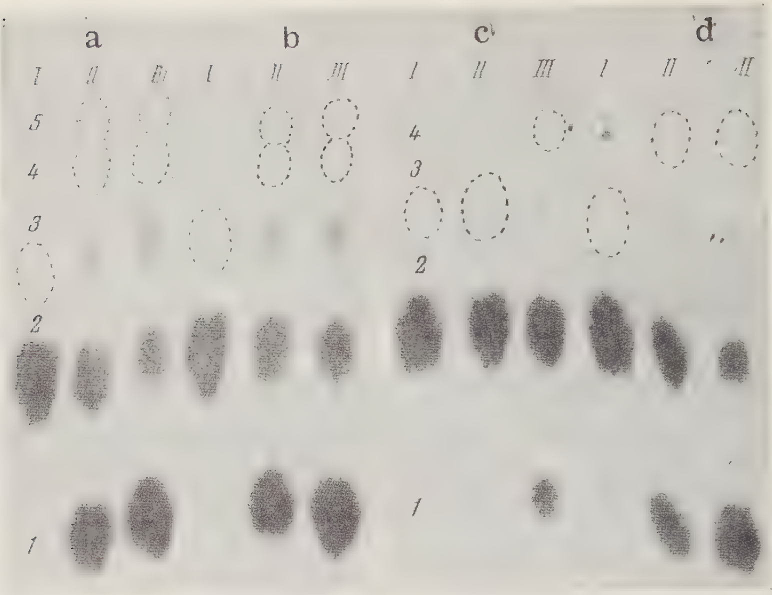

Fig. 1. - Inhibition of soil maltase activity.

A - without inhibitor; B - with dihydrostreptomycin; C - with $AgNO_3$; D - with $HgCl_2$. I - substrate; II - soil without substrate; III - soil plus substrate (maltose). Solvent: propanol-ethyl acetate - water (6:1:3) Developer: $AgNO_3$. 1. glucose; 2. maltose; 3. isomaltose; 4-5. reducing oligosaccharids.

traces are identical in each treatment; that is, the inhibitors studied do not act upon the substrate. In samples II and III, apart from the spots of maltose and the product of its hydrolytic decomposition (glucose), spots of isomaltose and other reducing oligosaccharids can be detected. This means that soil maltase is a glucose transferring agent, which acts as a catalyst not only for hydrolytic but also for synthetic reactions.

Comparing samples II and III in the different treatments we see that the maltose spots are more clearly visible in the first case but that the glucose and oligosaccharid spots are more intensive in sample III (particularly in treatment C); in other words, the activity of maltase in these samples was higher than in those without the substrate. This means that maltose added into the soil makes for an increase in its maltase content.

Comparison of treatment A (without the inhibitor) with treatments B, C, and D shows that dihydrostreptomycin lowers the activity of soil maltase very little. Silver nitrate exerts a marked inhibiting effect: glucose and oligosaccharids are formed in considerably smaller amounts in its presence under the influence of maltase than in the treatments without this inhibitor. The inhibiting action of mercuric chloride is less pronounced than that of silver nitrate but stronger than that of dihydrostreptomycin.

Although the concentration of the inhibitors studied in the reaction mixtures was very high, their inhibiting action on maltase was only partial; that is to say, soil maltase is resistant to inhibitors. This observation introduces new data in favor of the protective action of the soil in regard to enzymes, shown in their resistanc to microbic decomposition (12, 18, 8, 5, 6, 16, 7, 4, 15) as well as to the inhibiting action of clay minerals (23), and other substances (21, 22, 24, 15).

Chromatographic analysis of the control rea tion mixture (soil plus dihydrostreptomycin wit out maltose) did not reveal any signs of enzyma tic decomposition of the dihydrostreptomycin. This agrees with Barker's figures (10) showing that an acellular enzyme from an Aspergillus niger culture cannot hydrolyze streptomycin. Our observations are of a more general character, since the soil contains enzymes produce by various microorganisms.

Conclusions

1. Soil maltase is a glucose-transferring agent and is accordingly capable of acting as a catalyst not only for hydrolytic but also for synthetic reactions.

2. Application of maltose to the soil increas the production of maltase by soil microorganisms.

3. Although the concentration of the inhibitors studied (dihydrostreptomycin, $AgNO_3$, and $HgCl_2$) in the reaction mixtures was sufficiently high, their inhibiting action on the soil maltase was only partial. This indicates that the soil

erts a protective effect on maltase.

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IETHODS FOR STUDYING SOIL DAMAGE WHEN EROSION OLLOWS CLEAR CUTTING OF MOUNTAIN FORESTS

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gricultural Afforestation

Major cutting of forests often lead to a
arked decline in the conditions for forest
rowth. Thus, clear-cuttings on level areas
reatly deteriorates the physical properties of
oils (5), and in the mountains there is also
tensive erosion. This leads to a decline in
oil fertility and in the productivity of stands.
here are very few references in either the
oviet or the foreign literature regarding dif-
erent types of cutting and subsequent erosion
damaging the soil, especially in relation
mountain forests, and the existing methods
r studying these phenomena are not always
pplicable.

The most reliable methods for studying
rosion phenomena are, as is known, perma-
ent studies on small catch basins (10) and on
unoff areas (17, 4, 2). But these methods
volve capital expenditure and lengthy obser-
ations and it is very difficult to apply them to
udy the countless factors affecting erosion
nder mountainous conditions. The sprinkling
ethod (7, 16, 14, 15) requires expensive equip-
ent and cannot be used to study the effect on
e intensity of erosion of such important fac-
rs under our conditions as the length (depth)
the slope, the nature of the tree canopy, etc.

The prevailing methods for studying erosion
common use — calculation of washout from
e volume of water channels formed (8, 6, 13),
e pin methods (1), the method using control
ants (12), — are scarcely applicable to moun-
in conditions. The metallic rod method de-
ribed by Kittredge (9) also has fundamental
awbacks.

Erosion on forest clearings is closely related
the degree of damage to the soil in forest utili-
tion, mainly from timber logging, and one
ould therefore determine the nature (degree
damage) of the soil before studying erosion
enomena. A six category classification has
erefore been worked out: 0 — no damage;
— litter loosened; II — litter removed and
per soil horizon loosened; III — linear dam-
e (skid trails) of varying depths; IV — linear
sheet damage; V — deposits. Categories III
d IV are subdivided into three further cate-
ries: IIIa — depths of damage down to 5
ı, IIIb — 10 cm; IIIc — 30 cm; IVa — 5 cm;
b — 10 cm; IVc — 50 cm. This compara-
ely detailed division into categories and sub-categories is required in certain cases owing to great differences in the intensity of erosion on plots on which the degree of damage varies.

A specially prepared sectional grid (Fig. 1) is placed on the soil in the upper, middle, and lower parts of the slopes to establish the percentage distribution of damaged areas of the different categories and sub-categories in a forest cut-over area. This simple device consists of four wooden strips screwed together at the corners. Nails are driven into the strips' at 10 cm intervals. Twine is stretched between the opposite nails to form a 1.0 x 1.0 m frame divided into 100 equal squares with a 10 cm side. When this grid is placed on the soil the number of squares (and therefore the percentage) of any category of soil damage can be determined without the need for laboratory calculations. We found in practice that 50 uses of the frame evenly spaced over the area were sufficient to yield reliable results.

We give as an example data (Table 1) for damage to the surface of the soil for a cut-over after clear-cutting with haphazard logging in the winter, spring and summer (Transcarpathian region, spruce zone, Belo-Tissyan forest economy, compartment 14/5, length of slope 300 m, gradient 25°-28°).

Table 1 shows that haphazard logging in the winter does not seriously damage the soil in the summer it leads to a type of plowing of mountain slopes.

Simple methods were used to study erosion phenomena on plots with various categories of soil damage. Rectangular calculation areas 1 x 2 m with the long sides running along the horizontals of the slope were marked out on plots of the first, third, and fifth categories. Wooden posts 60 cm long were driven in at the corners and in the centre of the long sides (i. e., 6 posts per plot), 5-6 cm being left above the surface. The upper faces of the posts were carefully levelled and drilled through their geometric centers to take the specially prepared measuring device (Fig. 2). This device for the calculation of erosion consists of a ruler with 10 cm divisions. Metal rods on the end stops of this ruller fit into the holes drilled in the posts. A vertical ruler with a mallimeter scale

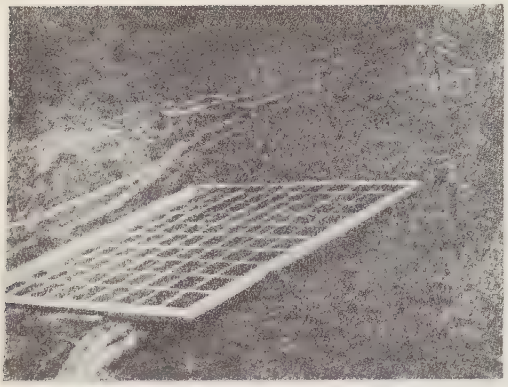

Fig. 1. - Grid for studying the condition of the soil after cutting and logging in a forest area (photograph A.F. Polyakev).

slides freely along the horizontal ruler on a wooden slide. The base area of the vertical rule is 1 cm². Spring clips fasten the horizontal scale at 10 cm intervals by entering grooves on the surface of the horizontal ruler.

A screw spring holds the vertical ruler secure on its mount. When the spring is released the ruler moves up and down easily.

This simple device is mounted on two neighboring posts so that the metal rods go right into the holes (the instrument is set up seven times on each area), the distance to the surface of the soil is measured on the vertical scale every 10 cm, i. e., there should be 70 measurements on each calculated area.

When these measurements are systematically repeated (annually in the spring, summer and autumn) reliable data on the dynamics of sheet erosion can be obtained. Calculated

Table 1

Soil damage in haphazard logging in a cut-over area in winter, spring, and summer

Parts of the clearing	Season	Categories of damage to the surface of the soil, %									
		0	I	II	III			IV			V
					a	b	c	a	b	c	
Lower	Winter	59,8	24,1	8,6	2,9	—	—	3,1	—	—	1,5
	Spring-Summer	31,4	26,2	8,4	9,8	2,6	0,7	9,3	2,7	3,7	5,2
Middle	Winter	60,3	22,6	8,5	4,8	—	—	2,1	0,3	—	1.4
	Spring-Summer	39,3	23,8	9,3	9,1	1,6	—	8,2	1,1	2,4	5,2
Upper	Winter	63,5	21,6	7,2	3,4	—	—	2,0	1,1	—	1,2
	Spring-Summer	44,7	21,0	11,0	8,7	1,5	—	6,1	1,3	1,8	3,9
Averaged data	Winter	61,2	22,8	8,1	3,7	—	—	2,4	0,5	—	1,3
	Spring-Summer	38,5	23,8	9,5	9,3	1,9	0,2	7,8	1,8	2,5	4,7

Note: Comma represents decimal point.

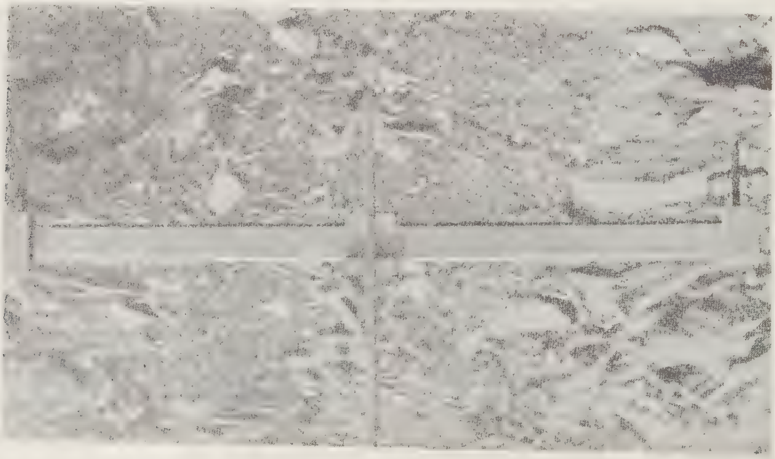

Fig. 2. - Ruler for calculating erosion (photograph A.F. Polyakev).

ections were selected to study concentrated rosion in skid trails (linear and linear-sheet amage of categories III and IV). Unlike the alculated areas these were 10 m sectors of kidtrails. At the ends of these sectors and the middle two posts were driven in on ach side of the skid trails (six posts in all). he apparatus previously described was mounted n each pair of posts and the sectional profile f the skid trails was measured every 10 cm. hanges in the skid trails were studied by reeated measurements.

To allow for the influence of the extent of ie slope and the dimensions of the water atchment area the calculated areas and secons were laid out in the upper, middle, nd lower sectors of the cut-over areas at inervals of 50-100 m within each sector in relaon to the given problems. The condition of the oil surface had to be established in 4-6 secons or areas on plots of each category.

To determine the volumetric indices of rosion on a whole cut-over area it is only ecessary to take average values of the eroded oil horizon by the categories and sub-cateories and to multiply them by the area occuied by these categories and sub-categories nd add up the sum. The areas occupied by the arious categories can easily be determined rom the percentage distribution data (see above).

It is convenient to mention here that the wooden osts should preferably be of oak since they last or a long time in the soil. Metal posts were ess satisfactory.

In addition to this method for studying soil rosion we have also used metal posts with right angle bend at the top and metal posts ith rulers attached. The first posts were made of 2 cm angle iron. The post was 60 cm long to the angle and the length of the right angle extension was 13 cm. The extension was made rectangular for ease in measurement. The distance to the surface of the soil could be measured with sufficient accuracy by lining an ordinary ruler up against the flat surface. The posts with rulers were also prepared from a round iron bar 60 cm long to which metal rulers with 1 mm divisions were firmly attached. Erosion was observed with these rods by periodic measuring of the height of posts projecting above the surface by the measuring rulers.

To prevent corrosion the posts and rulers were heavily vaselined before being buried in the soil. The posts were sited on the experimental areas in relation to the classification of soil damage already described.

All these methods for studying erosion were tested on the same experimental production cut-over areas in the Tur'ya-Remetsk Forest in the Transcarpathian region. Observations over a period of four years showed that our method of calculation areas and sections gave the most reliable results on experimental areas.

The use of right angle posts only gives reliable values when a large number of posts are used on each area being studied. In our experiments this method failed to give satisfactory results.

The use of metal posts and rulers has the same drawback as the preceding method. It also distorts erosion data owing to the fact that the continuity of the soil is destroyed when the posts are driven in. Finally, various organic residues and fine earths often accumulate on the sides of the posts facing the top of the slope.

Table 2

Erosion dynamics on a clear-cut area

Categories of the surface condition	Observations, year	Average value, cm		Area occupied by the categories, m²	% of area on which observed		Erosion processes, m³/ha			Maximum erosion, cm
		Erosion	Deposition		Erosion	Deposition	Eroded	Deposited	Carried away	
I	1955	1,1	3,0	1040	35	65	4,0	2,3	1,7	5,4
	1956	1,2	4,0	"	35	65	4,4	3,1	1,3	3,1
II	1955	1,3	1,2	1230	65	35	10,5	5,2	5,3	5,3
	1956	1,2	8,0	"	60	40	8,8	4,2	4,6	4,2
III	1955	1,7	2,0	620	90	10	9,4	1,2	8,2	4,3
	1956	1,1	1,1	"	75	25	5,0	1,7	3,3	3,6
IV	1955	11,7	4,8	2740	60	40	192,0	52,0	140,0	25,2
	1956	9,8	5,2	"	50	50	134,0	71,0	63,0	24,3
V	1955	8,7	4,2	2880	72	28	180,0	34,0	146,0	23,1
	1956	4,1	3,2	"	60	40	71,0	37,0	34,0	22,4
Total	1955	—	—	8510	—	—	396,9	95,7	301,2	—
	1956	—	—	"	--	—	223,2	117,0	106,2	—

Note: Comma represents decimal point.

We give some data for a 2 year study of erosion on an experimental plot of clear-cut area.

This plot is situated in the Tur'ya-Polyansk forest of the Tur'ya-Remetsk forest, on a southwesterly slope with a gradient of 32°, its height above sea level is 600-900 m, the soil is brown earth and of medium thickness, the type of forest according to Vorob'yev (3) is humid pure Carpathian beech.

In 1955 a highly productive stand of site quality I consisting of 10 beech, single sycamore, ash, and elm was cleared on this plot. The timber was removed from the cut-over area (haphazard logging). In the same year eight calculated areas and twenty-two sectors were laid out on the lower, middle, and upper parts of the slope in the experimental clearing. The results of these studies differentiated within the limits of the categories are given in Table 2.

Conclusions

1. The proposed classification of damage to the soil describes the changed condition of the soil from forest exploitation with sufficient details.

2. The method of calculated areas and sectors in which erosion is determined by our apparatus, should be acknowledged to be the best method for studying erosion.

3. If it is to yield reliable results, the method of right angle posts requires a large number of posts, it is not suitable for studying changes in the profiles of water channels and the posts are not sufficiently resistant in the soil.

4. In addition to the drawbacks of the previous method, the method using posts and rulers distorts the results owing to destruction of the continuity of the soil and to the accumulation around the posts of fine earths eroded higher up the slope.

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EFFECT OF DEGREE OF SOLONETZIZATION OF SOIL ON TREE GROWTH IN POT EXPERIMENTS

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Solonetzic horizons possessing unfavorable physical properties (low air and water permeability, absence of agronomically valuable structure and so forth) create conditions which hamper the normal growing activity of roots. This leads to reduced tree growth, early aging and even complete loss of the trees.

Under natural conditions it is difficult to trace the influence of solonetz horizons on the growth and development of trees, since the horizon beneath the solonetzic part of the soil profile is saline with readily soluble salts. The unsatisfactory condition of windbreak plantations on solonetzes and solonetzic soils is rightly at-ributed to the combined influence of the poor physical properties of the solonetz horizons, the unfavorable water regime, and the salinity of the root layer where the reaction of the soil solu-ion is alkaline (2).

In order to study the forest growth proper-ies of a compacted illuvial solonetz horizon n a subzone of the dark chestnut soils, we set up pot experiments, on the assumption that the problem could be solved in this way. By mixing he solonetzic layer in various ratios with the op horizon of the dark chestnut soil we obtained a soil with varying content of exchangeable sod-um, which we placed in the pots.

A columnar horizon of fine clay loamed solonetz and the top 20 cm layer of the humus horizon of a dark chestnut fine clay loam soil rom the Kletskiy experiment station of the All-Union Institute for Scientific Research on Agricultural and Forest Melioration (VNIALMI), Stalingrad Oblast' were taken for the purposes of the experiment. The surface horizon of the dark chestnut soil and, separately, the solon-tzic horizon were brought to air dry condition, ground, and then passed through a sieve with 2 mm diameter openings. From the samples so prepared, mixtures were made in the following weight ratios.

Treatment I — pure solonetz horizon;

Treatment II — solonetz horizon in mixture with 25% dark chestnut soil;

Treatment III — solonetz horizon in mixture with the same quantity (by weight) of dark chest-ut soil;

Treatment IV — solonetz horizon in mixture with 75% dark chestnut soils;

Treatment V — pure humus horizon of the same soil.

The different mixtures had the following composition in regard to adsorbed cations (Table 1).

In this way we were able to obtain a series of soils with a different content of adsorbed sodium and consequently a different degree of solonetzization. The amount of exchangeable sodium in the well-defined columnar horizon was about 13% of the exchange capacity and according to Antipov-Karatayev's classification, such a soil should be classed as moderately solonetzic (1); according to Sadovnikov's classification (4) it is a solonetz. We may provisionally regard treatment II as strongly solonetzic, III as moderately solonetzic, and IV as only slightly solonetzic.

The content of water soluble substances, according to the values obtained from a 3 minute water extract in the main treatments are shown in Table 2.

In this case, too, a gradual reduction both of the total amount of water soluble substances and of particular cations and anions was observed as a result of the mixing, from the solonetz to the dark chestnut soil.

In the solonetz horizon the chloride content amounted to 0.08% at a total alkalinity of 0.07% HCO_3, which, it would appear from the values given in the literature, can have a depressive effect on certain trees (3). In the pots, however, at a constant moisture of 60% of total moisture capacity, this depressive effect must be considerably mitigated. In the other treatments of the experiment the chloride and carbonate salt content was below the permissible standards given in the literature for ordinary tree vegetation.

In treatment I, in solonetz, both the alkalinity and the salinity of the soils appears to have exerted a depressive effect on the plants; in treatments II, III, IV, and V, the influence of the salt composition on the growth and development of the plants was less in comparison with the

Table 1

Cation adsorption (Gedroyts method)

Experimental treatment	Adsorbed cations, meq				Na^{+} (in % of total adsorbed cations)
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
I. Pure solonetz horizon	26,00	8,94	5,33	0,26	13,1
II. 75% solonetz horizon + 25% dark chestnut soil	27,50	7,97	4,35	0,26	10,8
III. 50% solonetz horizon + 50% dark chestnut soil	30,00	4,83	3,55	0,33	9,2
IV. 25% solonetz horizon + 75% dark chestnut soil	32,00	4,47	2,52	0,41	6,4
V. Dark chestnut soil	34,00	3,58	0,95	0,59	2,4

Note: Comma represents decimal point.

Table 2
Analysis of water extract on absolute dry soil

Treatment	Hygroscopic moisture	Dry residue	Total alkalinity in HCO_3	Cl^{-}	$SO_4^{=}$	Ca^{++}	Mg^{+}
	%						
I. Pure solonetz horizon	5,40	0,81	$\frac{0,066^{a}}{1,080}$	$\frac{0,084}{2,390}$	$\frac{0,050}{1,030}$	$\frac{0,005}{0,260}$	$\frac{0,013}{1,110}$
II. 50% solonetz horizon + 50% dark chestnut soil	3,58	0,27	$\frac{0,035}{0,600}$	$\frac{0,038}{1,090}$	$\frac{0,035}{0,750}$	$\frac{0,006}{0,300}$	$\frac{0,007}{0,640}$
V. Dark chestnut soil	2,90	0,05	$\frac{0,007}{0,120}$	$\frac{0,004}{0,133}$	$\frac{0,013}{0,280}$	$\frac{0,010}{0,530}$	$\frac{0,006}{0,500}$

[a] Numerator — percentages; denominator — meq.

Note: Comma represents decimal point.

influence of physical properties as a result of the non-uniform amount of exchangeable sodium.

The humus content in treatment I was 1.04%; in III, 2.38%; in V, 3.58%.

The amount of soil in each pot was 3.2 kg, the depth of the pot being 30 cm, and its diameter, 16 cm. The experiments were replicated 3 times for each tree under investigation, except the oak, for which the test was replicated twice. Four seeds of each plant under investigation were sown in each pot. When the shoots appeared they were numbered and then described and measured every 3 days at the beginning of the growing period and every 10 days later on. The pots were watered both from below and from above. The moisture was kept constant at 60% of total moisture capacity. After the end of the growing period the plants were carefully taken out of the pots so that the root systems could be studied, the weight determined, and so forth. The test subjects were white acacia, honeylocust, English oak, and Siberian larch.

White acacia. Germinated white acacia seeds collected from the selection plot of the VNIALMI were sown on May 7, 1954. The depth of sowing was 0.5 cm. The addition of a columnar solonetz horizon to the humus layer of a dark chestnut soil led to reduction in the subsoil germinating capacity of the white acacia.

In the first month of life, the growth of the acacia in terms of height was the same in all treatments. Later, a marked retardation of growth set in, in the solonetz and in the treatment in which 25% dark chestnut soil was added to the solonetz. In september, the increment

Table 3

Height, total weight, and length of root system of white acacia

Treatment	Height, cm			Total weight of plant, g	Length of root system, cm
	Average	Maximum	Minimum		
I. Solonetz horizon	20,70	24,00	18,00	1,59	35,90
II. 75% solonetz horizon + 25% dark chestnut soil	24,50	43,00	13,50	2,17	34,80
III. 50% solonetz horizon + 50% dark chestnut soil	30,70	39,00	24,20	2,93	26,10
IV. 25% solonetz horizon + 75% dark chestnut soil	37,90	53,10	26,50	3,45	28,80
V. Dark chestnut soil	31,50	53,50	11,00	3,43	30,30

Note: Comma represents decimal point.

of the acacia ceased in all treatments. In November, the plant was taken out of the plots and studied. The results are shown in Table 3.

The white acacias in the pots of treatments IV and V were found to have grown best and to be in the best condition. The addition of 25% solonetz soil to the humus horizon led even to a certain increase in the average height and otal weight of the plants. Further addition of solonetz horizons to the humus horizon brought about a depressive effect on the plants. It is nteresting that the length of the root system proved greatest in the pots containing the solonetz horizon and also in those containing 75% solonetz. In these treatments the growth also ceased earliest.

The values obtained from the pot experiment confirm the information in the literature indicating that the white acacia is to some extent tolerant to solonetzization.

Common honeylocust. Germinated seeds of the honeylocusts were sown on May 8, 1954 at a depth of 1.5 cm. Shoots appeared almost simultaneously in all treatments of the experiments. In the pots containing the solonetz horizon the plants had almost ceased to grow by the end of June; in the treatments II, III, and IV pots growth continued almost until the end of July; in the pots containing the humus horizon of the dark chestnut soil growth continued until September 10. The addition of solonetz to the humus horizon made for earlier cessation of growth. Comparing the growth curve of the honeylocust with that of the white acacia we see that under identical experiment conditions (particularly in treatments I and II), the honeylocust is the first to stop growing. This indicates that the white acacia is more tolerant to solonetzization.

The figures in Table 4 indicate that the common honeylocust grew best and was in best

Table 4

Height, total weight, and length of root system of honeylocust in pots

Treatment	Height, cm			Total weight of plant, g	Length of root system, cm
	Average	Maximum	Minimum		
I. Solonetz horizon	22,00	26,00	16,00	1,09	26,3
II. 75% solonetz horizon + 25% dark chestnut soil	30,10	26,00	25,00	2,19	33,3
III. 50% solonetz horizon + 50% dark chestnut soil	35,40	39,80	17,00	3,13	32,0
IV. 25% solonetz horizon + 75% dark chestnut soil	34,30	52,00	14,00	3,20	34,8
V. Humus horizon of dark chestnut soil	43,90	69,50	18,00	8,60	51,9

Note: Comma represents decimal point.

condition in treatment V, that is, in the pots with the humus horizon of the dark chestnut soil.

A definite pattern can be observed in the decrease in the height of the plants and the number of roots and also on the dry weight as a function of the degree to which the humus horizon was diluted with solonetz.

English oak. Seedling was produced on May 25, 1954 by germinating acorns from the Moscow Oblast' at such a depth that each acorn was covered with one-half cm layer of soil. The course of growth in regard to height was roughly the same in all the treatments until June 21. After this, growth began to be retarded in treatments I and II and after August 2 the growth of the young oaks in treatments III and IV also began to slow down. In the treatment V pots with the humus horizon of the dark chestnut soil, appreciable growth ceased only at the end of July. Consequently, the addition of the solonetz horizon to the humus horizon slowed down the growth of the young oaks in the first year of life (Table 5).

The addition of solonetz to the humus horizon led to a reduction in the average height and weight of the plants as in the case of the white acacia and the common honeylocust.

We may take it that the smaller the difference in the average height of the tree in the pots with the humus horizon and in those with the solonetz horizon, the more tolerant to solonetzization is the tree. The average height of the white acacias in the humus horizon pots was 1.5 times greater than in the pots containing the solonetz horizon; in the case of the English oak and the common honeylocust it was 1.9 times higher. Consequently, under pot experimental conditions, the white acacia proved more toler-

Table 5

Height, total weight, and length of root system of oak in pots

Treatment	Height, cm			Total weight of plant, g	Length of root system, cm
	Average	Maximum	Minimum		
I. Solonetz horizon	13,25	19,00	10,50	3,92	38,81
II. 75% solonetz horizon + 25% dark chestnut soil	12,40	19,50	8,60	3,69	38,47
III. 50% solonetz horizon + 50% dark chestnut soil	16,00	19,20	12,50	4,17	38,75
IV. 25% solonetz horizon + 75% dark chestnut soil	16,50	20,40	11,50	4,51	42,32
V. Humus horizon of dark chestnut soil	25,50	31,00	15,00	5,15	44,75

Note: Comma represents decimal point.

Table 6

Height, total weight, and length of root system of Siberian larch in pots

Treatment	Height, cm			Total weight of plant, g	Length of root system, cm
	Average	Maximum	Minimum		
I. Solonetz horizon	4,00	5,00	3,70	0,08	31,00
II. 75% solonetz horizon + 25% dark chestnut soil	5,10	7,00	4,50	0,10	27,00
III. 50% solonetz horizon + 50% dark chestnut soil	6 10	7,50	4,50	0,17	36,60
IV. 25% solonetz horizon + 75% dark chestnut soil	6,20	7,20	5,00	0,14	40,60
V. Humus horizon of dark chestnut soil	9,23	13,50	8,00	0,27	50,00

Note: Comma represents decimal point.

nt to solonetzization than the two other trees nder investigation.

Siberian larch. Germinated seeds of the berian larch were sown in the pots on May 18, 954. The seeds were gathered in the dendrolo- cal garden of the VNIALMI. Shoots appeared gether on the 4th and 5th day after sowing. In e first month and a half there was no appreci- ble difference in the development of the plants cept in the case of treatment I, where growth actically ceased 3 weeks after the beginning the experiment. In treatments II, III, and the growth started to decrease on July 25.

Good growth was observed in treatment V ith the dark chestnut soil, where the growth d not cease until September. The Siberian rch is therefore very sensitive to solonetziza- on (Table 6). The values in Table 6 indicate at the average height of the plants in the dif- rent treatments appreciably decreases as the lonetz horizon content in the pots is increased d that the average weight of the plants decreases proportion to the amount of solonetz horizon ntained in the pots.

The foregoing material indicates that under t experiment conditions the Siberian larch oved the most sensitive to the degree of lonetzization as compared with the white acia, oak, and common honeylocust.

Conclusions

1. A solonetz horizon of a medium-columnar e clay loam solonetz from a subzone of the rk chestnut soils had an unfavorable effect, der pot experiment conditions, on the growth d development of white acacia, common honey- cust, English oak, and Siberian larch. This pears to be due to the unfavorable physical alities of the solonetz horizon.

2. The addition of a top layer of humus horizon from the dark chestnut fine clay loam soil to the solonetz horizon reduced the content of exchangeable sodium in it and improved growth conditions for the trees. Only an addition of 50% (in weight) of the humus horizon to the solonetz soil, however, led to an appreciable increase in growth.

3. Of the trees studied under pot experiment conditions, the white acacia came first in point of solonetzization tolerance followed by the English oak, the common honeylocust and, last, the Siberian larch.

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VOLUMETRIC DETERMINATION OF THE SULFATE ION IN WATER EXTRACTS FROM SOILS BY COMPLEX-FORMATION METHOD

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The widespread gravimetric method of determining the sulfate ion in water extracts from soils is based on its precipitation by $BaCl_2$, filtering off, washing, igniting and then weighing the $BaSO_4$. Like all gravimetric methods, this entails prolonged and somewhat cumbersome operations in the determination. An attempt was made in the laboratory of the Department of Soil Geography at the Soil Biology Faculty of Moscow State University to determine the $SO_4^{=}$ in water extracts by titrating with B trilon, so as to obtain a quicker volumetric method than the gravimetric method.

The principle of rapid bulk determination of $SO_4^{=}$ is very simple. In a known volume of water extract acidulated with HCl, the $SO_4^{=}$ is precipitated by the excess of a $BaCl_2$ solution of known concentration. A known amount of $MgCl_2$ solution (also of known concentration) is then added. The mixture is heated to boiling point, left to stand for 1-2 hours and then, without filtering off the $BaSO_4$ precipitate of the excess $BaCl_2$, the mixture is titrated with B trilon of known concentration, after adding a buffer solution, in the presence of a black chromogen of wine red color until blue appears; i. e., in exactly the same way as in determining adsorbed calcium and magnesium.[1]

A control determination was made simultaneously. For this an amount of $BaCl_2$ + $MgCl_2$ mixture was poured on to the solution under investigation and also titrated with B trilon after a buffer solution had been added in the presence of the black chromogen.

Barium and magnesium, as bivalent cations, were titrated with B trilon. Knowing the amount of trilon which was going into the control determination and having determined the amount expended in titrating the excess $BaCl_2$, we found, for the difference, the number of ml of $BaCl_2$ combined with the $SO_4^{=}$. After multiplying this quantity by the trilon normality and converting from the sample taken to 100 g of soil, we obtained the $SO_4^{=}$ content in meq.

As can be seen from the foregoing description, the determination of $SO_4^{=}$ by B trilon is not direct but indirect, since we are titrating with the trilon not the $SO_4^{=}$ but barium and magnesium, that is, cations left in the solution after precipitation.

The addition of $MgCl_2$ during the precipitation of sulfate ion is needed because no specific indicator has yet been found for titrating barium in a complex-form and the equivalent point during the titration is established indirectly through magnesium. Chromogen forms a less stable compound with barium than with magnesium and therefore B trilon extracts barium from its complex with the indicator before it extracts magnesium. The color changes after the magnesium has combined with the trilon and this serves as an indirect indication of the equivalent point in the interaction of the trilon with the barium ions.

In calculating the $SO_4^{=}$ content allowance must also be made for the amount of trilon consumed in the determination of the calcium and magnesium compounds passing over into the water extract. The determination of these elements is in our opinion more conveniently performed in a separate sample of water extract rather than in the solution in which the sulfate ion will be determined.

The formula for calculating the $SO_4^{=}$ content in meq is

$$SO_4^{=} = \frac{A-(B-b)\cdot n\cdot 100}{C},$$

where A is the number of ml of trilon used in titrating the $BaCl_2$ and $MgCl_2$ poured on for precipitation (control determination); b the number of ml of B trilon used in titrating the calcium and magnesium cations in the particular sample; C weight of soil sample is grams corresponding to the volume of extract taken for the sulfate ion precipitation; n normality of trilon B solution.

Having established the possibility of using th method through testing it on sample solutions (we shall not give the analysis figures), we compared the results of determining $SO_4^{=}$ by the tri onometric and the gravimetric methods. For th purpose water extracts of two soils were analys for $SO_4^{=}$ content by both methods. The results are shown in Table 1.

From these values it is clear that the dis-

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[1] We considered it redundant in this instance to add the hydroxylamine and Na_2S solution in titrating, as is accepted practice in determining adsorbed cations.

Table 1

Comparative results of determining $SO_4^=$ by the trilonometric and gravimetric methods

Soil	Depth, cm	$SO_4^=$ by gravimetric method	$SO_4^=$ by trilonometric method	Discrepancy (%)
		in meq per 100 g of soil		
Solonchak soil, Stalingrad Oblast'	0—10	0,96	1,0	4,1
	10—20	1,7	1,8	5,8
	20—30	8,7	9,0	3,3
	40—50	15,3	15,5	1,2
	50—60	22,2	22,4	0,9
	80—90	5,6	5,6	0,0
Solonetz, Chelyabinsk Oblast'	50—60	2,9	3,0	3,0
	80—90	3,0	3,0	0,0

Note: Comma represents decimal point.

Table 2

$SO_4^=$ concentration in solution under study, meq	$BaCl_2$ solutions recommended	
	ml	normality
0,005—0,05	5	0,03
0,05 —0,1	5	0,05
0,1 —0,4	5	0,1
0,4 —0,7	10	0,1

Note: Comma represents decimal point.

epancy between the analysis results obtained
the two methods are in a number of cases
gligible (0.9%, 0.9%, 1.2%, and 3.3%). The
eatest deviations (4.0%, 4.4%, 5.8%) are
und mainly in the soils with the low $SO_4^=$ con-
nt as is natural. Titrating with trilon in
cases gave higher values for the $SO_4^=$ de-
rmination than the gravimetric method; the
ason would seem to be that the washing in
e latter method leads to certain losses of
e precipitate.

Conclusions

1. The trilonometric method of determining $SO_4^=$ in water extracts can be recommended for purposes of soil analysis as being much quicker than the gravimetric method while at the same time hardly inferior to it in point of accuracy.

2. In work with the gravimetric method the concentration of the precipitating reagent is of great importance. If there is not a sufficient quantity of it the results will be distorted. Too high a concentration leads to a loss of accuracy. Before precipitation, therefore, it is advisable to arrive at a rough estimate of the $SO_4^=$ concentration in the solution under study by comparison with a scale of sample solutions.

3. In determining the amount of $BaCl_2$ solution to be added during the $SO_4^=$ precipitation the following guide, Table 2, can be used.

At higher $SO_4^=$ concentrations the solutions for determination must be diluted or taken in smaller quantities.

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DETERMINATION OF AMMONIA EVOLVED FROM SOIL[1]

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Atmospheric ammonia is usually determined by its absorption in a 0.01 N solution H_2SO_4, then coloring the solution with Nessler reagent and comparing with the sample solution. We used this principle for determining the ammonia evolved from the soil. The ammonia was caught in wide-necked flasks according to the same principle as is used in determining soil respiration (1). The determination was performed as follows: a wide-necked (diameter 5 cm), flat-bottomed flask with a capacity of 1-1.2 liter was set on the soil surface, the edges of the flask being wrapped in paper to protect them from contamination, and the soil was sprinkled in. After 1-2 hours the flasks was taken up and quickly closed with a rubber stopper. A 20 ml of 0.01 N H_2SO_4 solution was added into the flask through a small aperture covered with the stopper. To absorb the ammonia the flask was vigorously agitated with sulfuric acid for 5-10 minutes. After this 10 ml of solution were transferred from the flask to a test-tube; 0.5 ml of Nessler reagent was added and the color compared with the color of the sample solutions (0.3142 g NH_4Cl was dissolved in a 100 ml volumetric flask and 20 ml of the original solution was added into a liter flask; 1 ml of this solution equals 0.02 ml NH_3). At the same time the atmospheric ammonia content was determined by the same method and the amount of NH evolved (in mg per m² per hr. or in g per ha pe hr. was calculated from the difference between the ammonia content in the two cases.

We determined the evolution of NH_3 from soil on peat-bog (Dmitrovskiy District, Moscow Oblast') and sod-podzolic (Iztrinskiy District, Moscow Oblast') soils. It did not prove possib to detect ammonia evolution in all the observed periods; this would seem to depend on variation

Table 1

Influence of exposure on accuracy of determination of NH_3 evolved from soil (g NH_3 per ha per hr)

Soil	Date	Exposure, hr			
		0,5	1	2	3
Peat-bog	June 14—57	—	9,0	9,05	7,60
"	August 22—57	—	4,35	4,35	4,33
"	Sept. 3—57	—	4,46	6,70	5,96
"	August 22—58	—	0,0	5,0	—
Peat-bog + 0.5% urea	August 2—58	18,0	14,0	12,0	—
	August 16—58	46,8	53,3	30,0	—
Sod-podzolic (sandy loam)	Sept. 16—58	—	—	1,81	1,50
Sod-podzolic (medium clay loam)	August 19—58	—	10	10	—
	Sept. 1—58	—	0,0	7,5	—
The same + peptone	Sept. 1—58	—	31,6	31,0	—

Note: Comma represents decimal point.

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[1] In connection with the problem of nitrogen (2) in soil science and agriculture, it is of interest to study the amount of possible nitrogen losses from the soil in gaseous form. In 1957-1958, at the suggestion of I. V. Tyurin, we worked on a method for determining the rate of ammonia evolved from the soil.

the hydrothermal conditions, favoring the nmonification processes and the evolution ammonia from the soil.

We observed ammonia evolution from the il primarily in the period when soil mois- re was highest, particularly in a warm riod. In order to establish the exposure, that the length of time it is necessary for the sk to stand, various periods were tried (0.5, 2 and 3 hours). It was discovered that in termining ammonia evolved from soil the ex- sure time must be 1-2 hours (Table 1). With hour exposure the results obtained were slightly too low, owing to the increased concentration of ammonia in the flask, resulting in disturbance of the normal gas exchange. When the rate of ammonia evolution from the soil is very high, as can be observed for example when fertilizers containing ammonia are applied to the soil (manure, urea and so forth), the exposure time must be reduced to 0.5-1 hour. The discrepancies between the parallel determinations were negligible (Table 2).

The ammonia content in the air varied according to our determinations from 0.000 to 0.002-0.003 mg per liter.

Table 2

Rate of ammonia evolution in dried out peat-bog and sod-podzolic soils

Soil	Plot	Observation date	NH$_3$ evolved in g per ha per hr			
			1	2	3	Average
Peat-bog	Grasses	June 14, 1957	9,0	9,0	9,0	9,0
Same	"	June 20	4,60	4,60	—	4,60
"	"	July 15	4,32	4.32	4,32	4,32
"	"	July 23	19,2	19,2	19,2	19,2
"	"	August 12	6,65	19,9	19,9	15,4
"	"	Sept. 5	15,4	15,4	19,8	16,9
Sod-podzolic (sandy loam)	Grasses	June 14	1,81	1,81	1,81	1,81
	"	July 23	2,15	2,15	2,15	2,15
Same	"	August 15	0,0	4,50	4,50	3,0
"	Fallow	Sept. 6	4,44	4,44	4,44	4,44
Peat-bog	Grasses	June 4, 1958	5,0	5,0	5,0	5,0
Same	Fallow	August 9	10	10	10	10
"	"	August 16	20	30	20,20	25
"	Grasses	August 16	10	10	10	10
Sod-podzolic (medium clay loam)	Fallow	June 18	20	30	20,20	25
	Grasses	June 18	0,0	0,0	0,0	0,0
	Fallow	Sept. 1	7,5	7,5	7,5	7,5
	Grasses	Sept. 1	2,5	2,5	2,5	2,5

ote: Comma represents decimal point.

Table 3

Rate of ammonia evolution in experiment with application of urea (22 July) in peat-bog soil

Date	Control	0.1% urea	0.5% urea
	NH$_3$ evolved (g per ha per h)		
ly 25	0,0	11,0	57,5
ly 29	13,8	107	496
ugust 2	0,0	53,3	180
ugust 9	10,0	40,0	127
ugust 22	5	5	5

e: Comma represents decimal point.

In order to increase the rate of ammonia evolved from the soil and check the suggested method we applied urea and peptone to the soil, allowing 0.1% and 0.5% nitrogen by weight to the soil. In this case, as Table 3 shows, distinct differences appeared for each of the treatments in the values obtained for the rate of ammonia evolved from the soil. This may be taken as a positive assessment of the method proposed.

The determinations showed (Table 2) that the rate of ammonia evolved from the soil during the growing period varies in dried peat-bog soils and sod-podzolic medium clay loam soils from 0.0-4.5 to 25 g NH$_3$ per ha per hr. At certain moments during the growing period the nitrogen losses from the soil (in the form of gaseous ammonia) can be considerable.

The proposed method of determining the rate of ammonia evolution from soil is distinguished by its simplicity, requires no complicated apparatus, and permits the determination to be made directly in the field.

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MPROVED METHOD FOR DETERMINING ADSORBED AMMONIA N THE SOIL

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It was pointed out in a previous paper (2) at in determining the adsorbed ammonium the soils of the Chui valley by extracting e ammonia with 1% KCl solution at a 1:10 il solution ratio, and with prolonged (20 urs) interaction between the soil and the lution in the presence of toluol (3), hydroly- s of the organic forms of nitrogen in the soil kes place in soil salt suspensions, with the sult that this method takes into account not ly the adsorbed ammonium but also certain adily hydrolyzable organic nitrogenous com- unds. One of the arguments in favor of the esence of such hydrolysis was based on lues given, showing that the ammonia yield the soil salt suspensions appreciably in- eased when organic compounds containing rogen in amide form were added.

This paper gives the results of further re- arch on this question, directed primarily find whether the hydrolysis indicated is a emical or a biological process.

The hypothesis that the organic nitrogenous mpounds in the soil salt suspensions undergo emical hydrolysis was based on values show- a marked increase in the pH when KCl in- racts with a carbonate meadow-sierozem il. Similar research with pure salts re- aled a similar rise in the pH (Table 1). This n occur according to the following scheme: $Cl + CaCO_3 = CaCl_2 + K_2CO_3$. Indications e to be found in the literature (9, 10) that ological hydrolysis of the amide forms of rogen in the soil is possible in the presence toluol, apparently owing to the action of il enzymes (amidases). It may be assumed at the action of these enzymes occurs also in il salt (KCl) suspensions.

A series of investigations was made to elu- late these questions. Table 1 shows the sults of verifying asparagine hydrolysis pure salt solutions and in soil salt suspen- ns (for the plowed horizon of the soil) with ferent pH values. Table 2 shows the results a second experiment, on the hydrolysis of paragine in salt (KCl) suspensions — first, a sample of the plowed horizon of a adow-sierozem carbonate soil; and second- for the same soil sample after various pre- inary treatments such as ignition, boiling h water, and sterilization of the west soil in eam from boiling water. The table also shows the hydrolysis of asparagine in a sample of meadow-sierozem carbonate soil taken from the 130-140 cm layer. The suspensions were in 100 ml solutions; $CaCO_3$, 0.4 g; soil, 10 g. A 40 mg of asparagine was added, corresponding to 425 mg of amide nitrogen per kg of soil. The interaction of the suspensions with the asparagine occupied in the presence of toluol. The values in Tables 1 and 2 indicate that the hydrolysis of the amide compounds in the salt suspensions was of a biological character.

Further investigations were made to find the influence of various conditions on the hydrolysis of amide nitrogen in soil salt suspensions with KCl (presence or absence of toluol or other antiseptics, different solution volumes and concentrations, different temperatures). The experiments were made with asparagine and urea. In the case of the urea a preliminary test was made for its resistance to the hydrolytic action of alkaline solutions. Urea proved more stable in this respect than asparagine. Results showed appreciable hydrolysis of the amide form of nitrogen even in the absence of toluol, although the addition of toluol somewhat intensified this process. The high degree of urea hydrolysis was also noted in the presence of other antiseptics such as chloroform and xyol.

When the soil-solution ratio was widened from 1:2 to 1:10, the degree of amide nitrogen hydrolysis increased by a factor of almost 3.

When the KCl concentration was increased from 1%-5% the hydrolysis of asparagine and urea slightly increased. Temperature exerts an appreciable effect on the hydrolysis of amides. A high degree of urea hydrolysis was noted even at the low temperatures of 6°-10° C, but when the temperature of the suspensions was increased to 20°-27° C the urea hydrolysis rate increased by a factor of 2.5, from 46-129 mg per kg of soil (converted to N).

Amide nitrogen hydrolysis occurred also in soil suspension, but rather less intensively than in the salt suspension. It was also established by the tests that hydrolysis occurs only in soil suspensions and not in a filtered extract, even when such an extract is allowed to stand for 20 hours (in the presence of toluol). The reason appears to be that the soil enzymes (amidases) are adsorbed on the soil and do not pass into the solution.

Table 1

Hydrolysis of asparagine in various salt suspensions. Ammonium nitrogen in mg per kg of soil

Extract No.	Composition of suspensions	pH of extracts	Ammonium N on prolonged interaction of soil with solution of hours		
			20	40	96
1	1% KCl + asparagine	5,6	Traces		
2	$CaCO_3$ + water + asparagine	7,2	"		
3	$CaCO_3$ + 1% KCl + asparagine	7,8	"		
4	$CaCO_3$ + 5% KCl + asparagine	8,0	"		
5	Meadow-sierozem carbonate soil + 1% KCl	7,7	8,7	11,8	33,0
6	The same + asparagine	Not det'd.	45,8	82,3	467,0
7	Water extract of the same soil	7,1	Not det'd.		
8	Mountain chernozem soil + 1% KCl	5,9	Not det'd.	25,7	Not det'd.
9	The same + asparagine	Not det'd.	"	188,0	"

Note: Comma represents decimal point.

Table 2

Influence of various preliminary treatments of meadow-sierozem carbonate soil (ignition, boiling, sterilization) on hydrolysis of asparagine added to it (28 hours interaction of soil with 1% KCl).
Ammonium N in mg per kg of soil

Extract No.	Preliminary treatment of soil	Ammonium N
1	Non-treated soil + 1% KCl	9,8
2	Non-treated soil + asparagine	130,1
3	Ignited soil + 1% KCl	Traces
4	Ignited soil + asparagine	"
5	Boiled soil + 1% KCl	5,6
6	Boiled soil + asparagine	3,8
7	Sterilized soil + 1% KCl	7,4
8	Sterilized soil + asparagine	6,4
9	Soil from 130 cm layer + 1% KCl	3,3
10	Soil from 130 cm layer + asparagine	4,4

Note: Comma represents decimal point.

All the values given, and also the results of other investigations show that there is a considerable difference in the hydrolysis of amides, depending on how long the soil suspensions are steeped, how often they are shaken up when left to stand for a long period, temperature conditions, the soil: solution ratio, and amount of amide nitrogen; the most important factor in increasing the hydrolysis of amide nitrogen in soil salt suspensions, however, is the interaction time. When the suspensions are shaken up for brief periods of 3-5 minutes and the extracts are quickly filtered, certain amide compounds (asparagine, acetamide) are not hydrolyzed at all and urea hydrolysis is negligible; more prolonged agitation of the suspensions (half an hour or more) causes appreciable urea hydrolysis (Table 3). If we take into account the high rate of adsorbed cation exchange, as distinct from hydrolytic processes caused by the biological activity of the soil, established by Gedroyts (1), this means that displacement of adsorbed ammonium from the soil without a supplementary hydrolysis process is possible only when the soil suspensions are agitated briefly and the extracts rapidly filtered.

Tests for the displacement of adsorbed ammonium from the soil with KCl solution were also continued. The results did not bear out the opinion expressed (2) to the effect that small quantities of adsorbed ammonium contained in the soils of the Chui valley can be completely displaced by means of a single treatment with 1% KCl solution. Further treatment with this solution, with brief shaking of the soil (when the hydrolysis action should not appear), yielded further quantities of ammonium. Some of the results from these investigations are given in Table 4.

It would appear that a single treatment of the soil with KCl solution displaces only readily

Table 3

Hydrolysis of urea in soil suspensions agitated for various lengths of time. Ammonium N in mg per kg of soil

Duration of shaking, minutes	Urea (amide nitrogen) added, mg/kg of soil	NH_4 nitrogen found	Difference due to urea hydrolysis
5	0	8,5	—
"	700	9,6	+1,1
30	0	9,1	—
"	700	13,5	+4,4
60	0	9,8	—
"	700	17,6	+7,8
120	0	10,2	—
"	700	26,1	+15,9

Note: Comma represents decimal point.

Table 4

Successive extractions of ammonium from soil. Soil:solution ratio 1:10. Ammonium N in mg per kg of soil

Sample No.	Successive treatment No.							
	1	2	3	4	5	6	7	8
1	5,89	1,20	0,96	0,67	1,16	0,61	0.97	0,91
2	4,70	1,17	0,85	0,79	1,16	0,85	0,91	0,91
3	5,22	1,01	0,67	0,87	0,90	0,43	0,59	0,42
4	3,80	0,75	0,45	0,67	0,97	0,43	0.79	0,63

Note: Comma represents decimal point.

changeable ammonium, whereas further eatment displaces ammonium which is more ·mly bound to the adsorption complex. A milar pattern has of course been established the case of other adsorbed cations, too.

The investigations also revealed the capacity meadow-sierozem soils to fix amounts of nmonium in non-exchangeable form; that is, a form in which they cannot be extracted en when the soil is repeatedly treated with n KCl. A slightly modified version of the ethod suggested by Ellison et al. (4) was ed for the investigations. Soil saturated th ammonium to 60% of the adsorption pacity and air dried at a temperature of 18° - °C was washed in 1 *n* KCl solution until the action to NH_4 disappeared. The original soil s washed in the same solution to eliminate exchangeable ammonium contained in it. all the soil samples so treated the total rogen content was determined by Kjeldahl's ethod. The results, shown in Table 5, owed that meadow-sierozem soils of the Chui lley can adsorb relatively small quantities ammonium (up to 39 mg per kg of soil) in n-exchangeable form, in contrast to the values obtained for certain soils by foreign investigators (5, 6, 11 and others).

In other samples of the same soil, when the method was applied under somewhat different conditions (washing the soil with 95% alcohol, after saturation with ammonium, until the excess NH_4Cl was removed and then drying it out), the non-exchangeable ammonium in the 50-100 cm layer amounted to 70 mg per kg of soil.

The values shown in Table 5 confirm those obtained by some authors (4, 7, and others) showing that nitrogen fixation in the form of non-exchangeable ammonium in the top horizon is low. These authors explain this as the result of considerable amount of non-exchangeable ammonium and potassium contained in this horizon of natural soil. It is very important to emphasize that a number of investigators have pointed out the low availability of non-exchangeable ammonium by plants and nitrifying bacteria (5, 6, and others).

The results of all the investigations, many of which are not described here for lack of

Table 5

Amount of ammonium adsorbed in non-exchangeable form on soil previously enriched in NH_4. N in mg per kg of soil

Depth, cm	Total nitrogen		Ammonium adsorbed in non-exchangeable form	
	In original soil (a)	After satr. with ammon and washing with 1 n KCl (b)	(b) - (a)	As % of (a)
0—30	1340	1346	+6	0,4
30—50	765	788	+23	3,0
50—100	515	654	+39	6,0

Note: Comma represents decimal point.

space, give basis for believing that three forms of adsorbed ammonium can be distinguished in the Chui valley soils, according to the strength of their combination with the adsorption complex: 1) readily exchangeable, extractable with a single treatment of the soil with 1% KCl solution; 2) exchangeable with difficulty, extractable only with repeated treatment of the soil with the solution; and 3) nonexchangeable, not extractable even with prolonged washing of the soil in 1 n KCl solution.

Various experiments were made to verify the presence or absence of hydrolysis when natural soil was treated with KCl solution without the addition of amide compounds. We cannot here go into details of experiments with subsequent extraction of ammonia from sterilize and non-sterilized soil samples. The investigations were made by treating sterilized and non-sterilized soil samples five times in succession with a 1% KCl solution and allowing brief interaction of the soil with the solution (soil solution ratio 1:6) and applying a sixth treatment with brief and prolonged interaction between the soil and the solution (20-68 hours). The object here was first to extract from the soil the greatest possible amount of ammonia, with the least hydrolysis of organic nitrogen (first five treatments); with the sixth treatment, only a small amount of ammonia was extracted, with the result that the hydrolytic action could be distinguished more clearly (difference between the ammonia yield resulting from brief interaction of soil with the KCl and that resulting prolonged from interaction) as well as the difference between the sterilized and the non-sterilized soil.

The experimental results (Table 6) indicate that a biological hydrolytic process also takes place in the natural soil: the first five successive treatments, with brief interaction of the soil with KCl solution, yielded very much the same amount of ammonia in the sterilized and in the non-sterilized soil samples. The same phenomenon was observed in the case of the brief soil-solution interaction in the sixth treatment. When the interaction time, however, was increased to 20 and 68 hours in the sixth treatment, the extra ammonia yield was 4 and 5.6 times higher in the non-sterilized than in the sterilized soil (column 6).

In order to check whether the biological activity of the soil in regard to amino-compound hydrolysis was maintained after many successive treatments with KCl solution, the following further tests were made. After adding 100

Table 6

Influence of soil-KCl interaction time on displacement of NH_4 when non-sterilized and pre-sterilized soil samples were subjected to successive extractions. Ammonium N in mg per kg of soil

Soil	Sample No.	Total ammonium extracted in first five treatments	Sixth treatment			Seventh treatment, 48 hours interaction	
			Duration of soil-KCl interaction, hours	Ammonium N	Ammonium N increment due to longer interaction	Urea N added, mg/kg of soil	Ammonium N found
Without sterilization	1,2,3	7.58	Brief	1,28	—	—	—
	4	7,52	20	5,82	+4,54	0,0	8,25
	5	7,38	»	5,70	−4,42	933,0	296,0
	6	7,40	68	8,90	+7,62	—	—
Sterilized	7,8,9	7,33	Brief	1,05	—	—	—
	10	7,49	20	2,22	+1,17	0,0	2,48
	11	7,31	»	2,15	+1,10	933,0	2,80
	12	7.22	68	2,40	+1,35	—	—

Note: Comma represents decimal point.

l of 1% KCl solution to non-steralized soil
rom samples 4 and 5 which had been left on the
ilters after the sixth treatment, and to ster-
lized soil from samples 10 and 11 (after 20
ours interaction of the soil with KCl during the
ixth treatment), the suspensions were again
eft for 48 hours and periodically shaken (seven-
h treatment of the soil) then urea was added to
uspensions 5 and 11 and suspensions 4 and 10
vere left urea-free. As can be seen from col-
mns 7 and 8 in Table 6, urea hydrolysis was
ntensive in suspension 5 of the non-sterilized
oil, whereas in suspension 4 of the same soil
n appreciable additional ammonia yield (8.25
ng per kg of soil) was observed. No urea hy-
rolysis occurred in the sterilized soil (sus-
ension 11) whereas the additional ammonia
ield from the same soil (suspension 10), ap-
arently from the extraction of non-readily ex-
hangeable ammonium, amounted to only 2.4 mg
er kg.

The results therefore show that when the
hui valley soils are treated with 1% KCl solu-
ion, slow, prolonged displacement of supple-
nentary amounts of adsorbed ammonium oc-
urs, and further, that on prolonged interaction
f the soil with the solution, organic nitrogen-
us compounds are apparently hydrolyzed biolog-
cally, with new formation of ammonia. It is
ot possible to find the borderline between the
wo processes. It is essential, for practical rea-
ons, to clear up the important question of how
ar the two forms of ammonium nitrogen (the
orm which is not readily exchangeable and that
vhich is produced in the process of hydrolysis)
re at any rate jointly available to plants. Ac-
ording to some figures the ammonium nitrogen
ield from repeated treatments can amount to 15-30 mg kg when the ammonium content in the first extract is not more than 4-8 mg per kg of soil.

At present, unfortunately, there is no direct method of evaluating the availability of ammonium nitrogen contained in the soil under various natural conditions. The following method was therefore used as a first approach to the question of plant availability of the two forms of ammonium nitrogen under consideration (all our knowledge of the high availability of adsorbed ammonium to plants is based on the results of experiments with soils artificially saturated with ammonium ion, and this form of ammonium is the only standard we have at present in considering the availability of adsorbed ammonium). In order to throw some light on this question, we conducted a series of experiments in comparing the course of events in extracting ammonia contained in natural soil with subsequent displacement of ammonium artificially adsorbed on the soil.

To obtain samples of soil artificially saturated with ammonium we used a meadow-sierozem soil which had previously been repeatedly treated with 1% KCl at a wide soil-solution ratio (1:15), the soil being allowed to interact with the solution for 24 hours at each treatment. This was done in order to remove in advance the greatest possible amount of adsorbed ammonium contained naturally in the soil and part of the organic nitrogen susceptible to hydrolysis (with new ammonium formation) in the salt suspensions. Soil samples so prepared were saturated with various amounts of ammonium from 8-40 mg per kg of soil.

Table 7 shows some of the results of the

Table 7

Successive extractions of ammonium nitrogen artificially added into soil and ammonium nitrogen contained in natural soil. Ammonium N in mg per kg of soil and in %

Form of adsorbed ammonium	Sample No.	Measurement units	Successive extract ion No.										
			1	2	3	4	5	6	7	8	9	10	Total
Artificially added	1	mg/kg of soil	4,3	0,7	0,5	0,4	0,3	0,2	Not det'd.				6,4
		%	68	11	8	6	5	2	"				100
	2	mg/kg	9,4	1,0	0,5	0,4	0,3	0,4	0,1	Not det'd.			12,1
		%	78	9	4	3	2	3	1	"			100
	3	mg/kg	17,4	1,8	0,4	0,5	0,3	0,3	0,2	"			20,9
		%	84	9	2	2	1	1	1	"			100
	4	mg/kg	30,5	2,1	1,4	0,7	0,6	0,6	0,6	0,5	0,3	0.3	37,6
		%	81	5	3	2	2	2	2	1	1	1	100
In natural soil	5	mg/kg	2,4	0,5	0,7	1,0	0,4	0,7	0,5	0,5	0,3	0,4	7,4
		%	33	7	9	14	5	9	7	7	4	5	100
	6	mg/kg	5,3	1,9	2,8	2,2	1,2	0,1	0,5	0,5	0,5	Not det'd.	15,0
		%	35	13	19	15	8	1	3	3	3		100
	7	mg/kg	5,3	2,3	2,2	2,4	2,3	1,4	1,6	1,4	1,3	1,3	21,5
		%	24	11	10	11	11	7	7	7	6	6	100
	8	mg/kg	6,9	5,7	3,5	3,9	2,4	2,9	1,1	Not det'd.			26,4
		%	26	22	13	15	9	11	4	"			100

Note: Comma represents decimal point.

successive displacement of artificially added and adsorbed ammonium from these soil samples, together with the course of successive extractions of the natural ammonium from the soil. The values indicate that there are marked differences in the character of the successive displacements of ammonium artificially added into the soil and adsorbed on it and the displacement of natural ammonium from the soil by extraction. The high percentage of displacement of artificially added and adsorbed ammonium in the first three successive treatments of soil with a low ammonium content deserves particular attention, since a low absolute content of adsorbed cations in the soils should be accompanied by a higher degree of adsorption in the form which is not readily exchangeable. It follows that whatever the nature of the total ammonium nitrogen yield from repeated treatment of natural soil with 1% KCl, it cannot be regarded as equivalent to the same amount of ammonium artificially added into the soil and adsorbed on it; in determining the ammonium nitrogen content in the soil for purposes of taking into account its availability to plants as a form of adsorbed ammonium, one must be guided mainly by the figures for a single treatment with KCl.

We also studied the importance of the soil: solution ratio in displacing ammonium by a concentration of KCl solution. In these experiments, where the soil suspensions were at first left to stand for 12 hours, the idea was to select the narrowest possible soil:solution ratio at which the maximum amount of readily exchangeable ammonium could be extracted with a KCl concentration within the limits 0.1% to 1.0%. The tests showed that higher KCl concentrations lead to larger amounts of Ca and Mg salts in the extract, which interfere with colorimetric evaluation of the solutions, whereas ammonium nitrogen yield can be increased by widening the soil:solution ratio, because of the more intensive hydrolysis of the amide compounds and the extraction of the ammonium forms which are not readily exchangeable. The absence of any substantial increase in the ammonium yield when the concentration was further increased at the narrowest possible soil:solution ratio served as a criterion on which to assess the choice of soil:solution ratio.

From this point of view the most acceptable KCl concentration at a soil:solution ratio of 1:4 proved to be 1% (Table 8). At narrower ratios and lower concentrations the amount of exchangeable ammonium extracted fell substantially, whereas the considerable increase in ammonium yield when the soil:solution ratio was widened to 1:10 and the soil suspensions were left to stand for a long time may be due to the reasons indicated previously.

With brief interaction of the soil with 1% KCl solution no great increase in the ammonium yield was obtained when the soil:solution ratio was widened from 1:4 to 1:10. With a soil:solution ratio of 1:4, 2.7-10.6 mg per kg was displaced from soil samples with a natural adsorbed ammonium content of the order 3-11 mg per kg; when the ratio was 1:10, the corresponding displacement was 3.3-11.0 mg per kg. Similar figures were obtained when larger amounts of adsorbed ammonium were added into the meadow-sierozem soils (27-90 mg per kg of soil). Under these conditions 78.1%-84.2% of the ammonium was displaced at a soil:solution ratio of 1:4 and 81%-89.3% at a ratio of 1:10. In both cases the percentage of ammonia displaced increased with increase of the soluble ammonium content in the soil.

Table 8[a]

Influence of KCl concentration on extraction of ammonium nitrogen at various soil: solution ratios. Ammonium N in mg per kg of soil

KCl concentration, %	Soil:solution ratio				
	1 : 1	1 : 1,5	1 : 2	1 : 4	1 : 10
0,1	2,9	3,2	3,8	6,1	8,5
0,2	4,1	4,5	4,3	7,2	9,2
0,5	5,1	6,0	5,9	7,9	9,4
1,0	5,6	5,9	6,6	8,2	9,8
5,0	6,4	6,9	7,2	8,5	9,4

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[a] In examining Table 8 all allowance must be must for the fact that the values for the different concentrations are fully comparable only within the limits of each individual soil:solution ratio, since the necessity of performing the tests many times over made it impossible to cover all the soil:solution ratios with the different concentrations at the same time. This condition (simultaneity) was observed only in regard to all the concentrations studied at a given ratio. The results obtained for the various ratios at the same concentrations are therefore not fully comparable. The various soil:solution ratios can be compared with one another only in regard to the effect of increasing the KCl concentration at each particular ratio. It was shown in the other papers (2) that the ammonium yield rises considerably as the soil:solution ratio is widened.

Note: Comma represents decimal point.

After all the tests had been made the following methodological conditions were accepted or displacing readily exchangeable ammonium rom the Chui valley soils: single treatment f the soil with 1% KCl solution, soil:solution atio 1:4, 5 minute shaking of the soil suspenions with quick filtering of the extracts.

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THE GP-21A FLAME PHOTOMETER

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The simplicity of the flame-produced spectrum of chemically complex substances, the high degree of accuracy with which certain elements can be determined by this method, and the stability with which the flame burns, have made it possible to construct simple flame photoelectric devices which have found wide application for purposes of analyzing the amounts of certain elements contained in different substances.

Flame photoelectric methods are becoming particularly important in soil science and agricultural chemistry because they make it possible to determine the potassium, sodium, calcium, magnesium, and certain other elements of importance in soil and agricultural chemical research.

Numerous modifications of flame photoelectric devices have been constructed in recent years, in which four main components can be distinguished: 1) a light source; 2) an optical device; 3) a light receiver; and 4) a measuring device. We shall examine the technical specifications, the working principle, and the design of the GP-21A flame photometer.

This instrument permits the determination of potassium, sodium, lithium and calcium in solutions, starting with a concentration of 1 mg per liter with an average degree of accuracy of the determination within the concentration range of 1-100 mg per liter ± 5 percent of the concentration to be determined. Given the appropriate light filters it is also possible to determine certain other elements, Sr, Cs, Ba, and others, without modifying the design of the photometer itself.

As a rule this apparatus makes it possible to perform the analysis when the elements to be determined are all present together in the solution, without preliminary chemical separation. This can be achieved by using interference light filters and compensation. The apparatus is designed for the use of an acetylene-air flame, a propane flame, and an illuminating gas. The theoretical scheme of the light source is shown in Figure 1, A (1 — air compressor (KVM-8) with motor; 2 — buffer cylinder; 3 — air filter; 4 — excess air remover; 5 — manometer; 6 — diffuser; 7 — acetylene generator (MGP-08); 8 — water seal; 9 — gas collector; 10 — acetylene dryer; 11 — pressure reducer; 12 — manometer; 13 — small needle-screw; 14 — burner.)

The air compressor ensures the required air at a pressure of 1 atm. The acetylene generator is hermetically sealed, allowing a discharge of up to 2 kg of calcium carbide, which is produced by approximately 500 liters of acetylene and is sufficient for some 200-300 analyses. The compressor and generator can be replaced by a cylinder supply without in any way modifying the design of other units in the photometer.

Figure 1 B is a diagram of the optical device. Light from the flame 1 passes through the lens 2, the aperture of the iris diaphragm 3, the grey light filter 4, and the interference light filter 5 which separates the radiation required so that the latter strikes the photocell 6. Spherical mirrors 7 are mounted in order to improve the sensitivity of determination. Neutral light filters which let through a half, a fifth, and a tenth serve to give a graded weaking of the radiation intensity in determining high concentrations or establishing the required degree of dilution of the solutions. The iris disphragms are used to compensate for photoelectric currents and changes in sensitivity of determination.

Selenium photocells (SF-10 or UF-101) are used as the light receivers for lithium, potassium and calcium, and silver sulfide photocells (FESS-UZ) for potassium. The monsuration instruments are M21-1 mirror galvanometers fitted with linear and logarithmic scales.

The four main units mentioned previously ar embodied in a fixed design, the layout of which is shown in Figure 1 C where 1 is the flame photometer,[1] 2 the galvanometer with the indicator scales, 3 — the compressor, and 4 — the acetylene generator.

Figure 1 D shows the general appearance of the flame photometer. The instrument is

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[1] The flame photometer proper is incorporated in the framework.

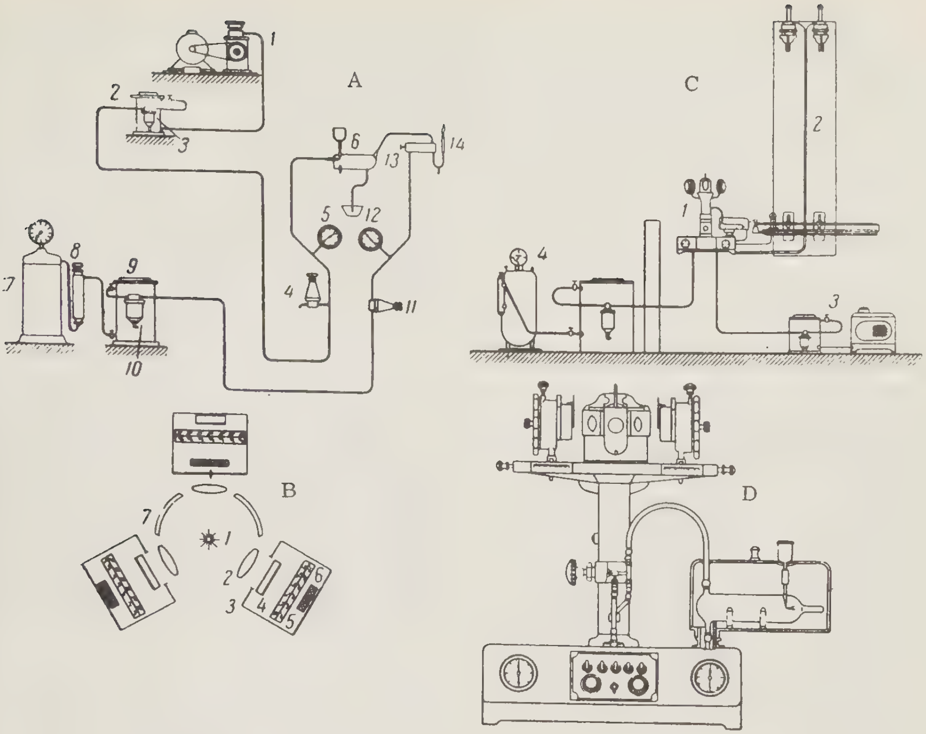

Fig. 1. - Layout of parts of flame photometer (for key, see text)

ntrolled from the front, rear, and side panels. he burner is made of metal and has a small ticular cap. The diffuser is made of organic ass and can function in two positions: the lution is either poured into a funnel and cked upwards or sucked downwards from crucible, in which case it must be rotated rough 180° and the funnel removed from e capillary section.

The photometric heads are similarly con- ructed and differ only in respect of the light ters and photocells. The photoelement, the terference light filter, the neutral light filter, d the iris diaphragm are mounted in the body the head.

The three heads are set at an angle of 120° one another and can easily be changed und. The lens is in front of the head and e spherical mirror opposite the flame. The otometer set includes four heads, with fferent light filters and photocells.

The instrument is equipped with two M21-1 lvanometers, on which are mounted rotating rrors wider than those in the standard odel, making it possible to work with a scale 0 mm long. The scale is linear — logarith- c and is common to both galvanometers. th this twin-galvanometer apparatus it is ssible to analyse two elements at a time vo independent channels) in terms of absol- e intensity or any one element in terms of rel- ve intensity. The electrical layout includes independent electrical correction of the galvanometers. A protective housing mounted on the photometer head brackets gives protection against outside light and keeps the flame steady against movements of the air.

It was pointed out previously that the interference light filters generally used in frame photometers do not make it possible to distinguish the individual radiation of a particular element. To some extent they let through the radiation of other elements as well, with the result that the analysis figures can be exaggerated or even completely wrong, depending on the ratio between the concentration of the element which is to be determined and that of the attendant element. The degree of exaggeration depends on the individual characteristic of the light filter designed to separate the radiation of the element to be determined.

In the case of the GP-21A it may be taken that on the average the photoelectric current excited by 100 mg per liter of calcium is equal to the photoelectric currents excited by 1 mg per liter of sodium or 0.5 mg per liter of potassium. Precise figures will be required for each individual instrument.

A number of methods are used in flame photometry practice to eliminate or allow for the interference of one element on the determination of another but they all mean that the analysis takes longer.

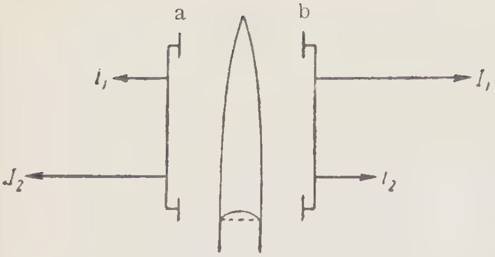

Fig. 2. - Diagram showing photoelectric currents in the photometric heads

a - Ca; b - Na

The compensation method embodied in the GP-21A automatically removes a wide range of the interference from one element in the determination of another as a result of insufficiently monochromatic light filters. As an example we shall take the determination of sodium by this method in the presence of calcium (Fig. 2.).

Two photometric heads are connected to the galvanometer in reverse polarity, one to determine the sodium, the other to compensate the calcium. When the diaphragms are fully opened and a solution of random concentrations of sodium and calcium is introduced into the flame, photoelectric currents I_1, i_1, and I_2, i_2 are excited in the photometric heads by the sodium and calcium, respectively. Then

$$I_1 = n \cdot i_1 \text{ and } I_2 = mi_2 \qquad (1)$$

The sum of the photoelectric currents registered by the galvanometer will be

$$I_1 + i_2 - I_2 - i_1 = I \qquad (2)$$

Depending on the sodium and calcium concentrations and the apertures of the diaphragms, I can be taken as a positive or negative quantity (deflection of the light beam to right or left). To effect the compensation we now introduce a solution of pure calcium salt into the flame. By manipulating the calcium head of the diaphragm we can reduce I_2 by a factor of m; that is, we can equate I_2 with i_2 and thereby eliminate the influence of the calcium. Under these conditions i_1 will also be smaller by a factor of m than its initial value and formula (2), with allowance for (1), will take the form

$$I_1 - I_1/n \cdot m = I \qquad (3)$$

In this way, by compensating for the photoelectric currents excited by the calcium we exclude the influence of the calcium on the sodium determination, although in doing so we introduce a slight but systematic reduction in the measurement of the sodium radiation intensity. If, for example, n = 20 and m = 25 this distortion will be 1/20 x 25 or 0.2% of the quantity to be measured. This does not affect the accuracy of the sodium determination, since the calibrated chart is constructed under compensation conditions.

Although it follows from the formula (3) that the compensation is correct for any concentrations of calcium, in practice there are limits to this condition, which we cannot go into here. Experience has shown that if compensation is effected for a calcium concentration of about 500 mg per liter, sodium and potassium solutions containing 1-1000 mg per liter of calcium can be analyzed. This range is sufficient for the vast majority of soil and other analyses. If, however, the same compensation is made in analyzing solutions containing 2000-3000 mg per liter of calcium, the results will be slightly too high; conversely, if the calcium compensation is effected in 3000 mg per liter when the calcium content in the solutions under analysis amounts to 1000 mg per liter, the results will be too low. This makes it necessary, especially with calcium concentrations higher than 1000 mg per liter, for there to be a (fairly rough) correspondence between the calcium concentrations in the solutions under analysis and the concentration for which the compensation is made. These considerations also apply to other combinations of elements (K-Ca, Li-Sr and others).

Comparing the GP-21A flame photometer with the similar Zeiss Model III, which is widely used in the Soviet Union, we find that the differences in design features in the individual components of the two instruments are not of substantial importance. We shall therefore not dwell on these. Experience of work under various conditions and with pure solutions shows that both are roughly equal as regards accuracy and performance.

The main advantage of the Model III as compared with the GP-21A is that it uses a bench galvanometer with a wide range of scale readings. Although the galvanometer is also sensitive to shaking it does not have to be attached to a sturdy support.

The drawback of this photometer is that, because it does not have sufficiently monochromatic light filters, it does not permit elimination of the influence of one element on the determination of another, with the result that the analysis values obtained are too high. In this respect the GP-21A has considerable advantages over the Model III.[2]

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[2] In a number of organizations, a second photometric head is mounted in the Model III flame photometer, and compensation effected.

I.P. REMEZOV, ON THE OCCASION OF HIS 60th BIRTHDAY AND 0th ANNIVERSARY OF SCIENTIFIC ACTIVITY[1]

V. DOBROVOL'SKIY

Nil Petrovich Remezov was born in Moscow
1899, and graduated from Moscow University
1923 with a degree in soil science. From
19-1921 he served in the Red Army. In 1921,
iile he was still a student, he began work in
e Department of Meadow Culture at the Mos-
w Institute of Animal Husbandry and in 1922
ansferred to the Samoylov Scientific Institute
Fertilizers. He remained in that Institute
ter taking his degree and worked there until
36, at first under the direction of his univers-
y teacher, Prof. V.V. Gemmerling, and
ter (1929) as Head of the Department of Soil
ience.

Remezov's first scientific work was a large-
ale soil survey of state farm and experiment
ation lands, including the Dolgoprudniy and
yuberetskiy experiment fields. From 1924
wards he studied the dynamics of the soil-
rmation process under experimental agricul-
ral crops in the Dolgoprudniy field. He made
particularly detailed study of the influence of
ning on the dynamics of soil processes.
ethods of determining the lime requirements
soils and instructions for liming were based
this work. In 1929-1931 he was a co-author,
th D. L. Askinazi and L. L. Balashev, of a
mphlet on the determination of lime require-
ents of soil and on instructions for liming.
iter (1938) the material on soil liming was
neralized by Remezov and S. V. Shcherba in
monograph The Theory and Practice of Soil
ming.

It was Remezov who in 1928 was the first to
ply an electrometric method in soil science,
r determining the oxidation-reduction poten-
l of soils. This is now common practice in
il research. In 1930, his textbook on colori-
etric methods of determining soil reactions
s published. During the same years the
ethod of determining the exchangeable acidity
soils by directly titrating salt suspensions
s worked out and introduced into practice. A
ndbook on physical-chemical methods of soil
search was issued in 1931.

These works show that Remezov was one of the first to promote the wide application of physical-chemical methods of soil research.

From 1929-1933 he directed a detailed (scale 1:2000) study of the soils of about 100 experimental fields in the European part of the USSR, Siberia, the Far East, Central Asia, and Transcaucasia. This research included studying the organic matter, soil colloids, and adsorption capacity of the main genetic soil groups in the USSR. The results were submitted to the Third International Congress of Soil Science and published in a series of papers in Pochvovedeniye during 1933-1938. Remezov has to this day retained his interest in the adsorption capacity of soils, as can be seen from his 1957 monograph Soil Colloids and Adsorption Capacity of Soil.

In 1933 he was appointed to the Chair of Soil Science and Geology at the Bryansk Institute of Forestry. Forest soil science now began to occupy an increasingly large place in his work.

At the Bryansk Institute of Forestry and later, from 1938-1942, at the All-Union Institute for Scientific Research on Forestry, he did a great deal of work on the study of soils and the soil-formation process in a number of forest areas for forest management purposes. This included detailed study of the organic composition of forest soils, the variations in their humus and bitumen content and the course of their ammonifying and nitrifying processes. He used this material for his doctorate thesis on the genesis of podzols, which he defended at the University of Moscow in 1941.

While directing the work of the Institutes of the Forest Soil Science Laboratory on forestry problems of immediate practical concern, he was also working on general theoretical problems. He attached particular importance to the study of nitrogen and ash element cycles in forests (see his paper on the tasks of a forest soil science laboratory, in the Transactions of the Institute, Pt. 24, 1941). The fullest treatment of this question is to be found in the works of Remezov and his colleagues in the soil science faculty of the University of Moscow.

Parallel with his work at the Institute, from 1938-1942 Remezov directed research, at the suggestion of the Moscow University-Institute

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Summary of paper presented at a joint session of
Scientific Council of the Soil Biology Faculty,
iversity of Moscow, and the All-Union Society of
l Scientists on December 2, 1959.

of Soil Science, on the soils of experimental plots in the sod-podzolic zone of the USSR. In 1942 he began full time work at Moscow University as Professor of Soil Science and until 1945 was Dean of the Geology and Soil faculties. Station observations on the biological cycle and soil-formation process under forest cover were made at the Voronezh State Reservation, the Moscow University Biological Station at Zvenigorod, and the Belovezhskaya Pushcha reservation. Work was started in 1954 on the relationship between biological accumulation and forest weathering and leaching processes in the Voronezh reservation. These observations yielded information and analysis results which form the basis for a revised idea of the seasonal, annual, and perennial cycles of the biological circulation of elements under forest cover.

During this period Remezov's study of the soils under the coniferous-broadleaf forests in the Russian plain justified him in classifying these soils as a separate group, which he suggested calling brown forest soils. The results of many years' research on the biological cycle of elements under forest canopy have in part been generalized in a recently published monograph by Remezov, Smirnova, and Bykova, Requirement and circulation of nitrogen and ash elements in forests of European part of USSR.

In 1956 Remezov presented summary papers on the role of the biological cycle in soil formation under forest cover at the All-Union Conference of Soil Scientists, and the Sixth International Congress of Soil Science in Paris.

The new propositions he advocated on the subject of the part played by forests in soil formation provoked lively discussion, as is usually the case when old views and theories are challenged and new ones gain force. This discussion cannot be regarded as over, but the systematic research done by Remezov and his co-workers over many years has certainly given us a much broader picture of the peculiarities of forest soils in regard to their genesis and properties, and is a creative development of Vil'yams contention that the task of pedology as a science is to discover the predominant trend and pace of the processes entailed in biological circulation.

The expansion and development of research on the biological circulation of elements is making it increasingly necessary both in the Soviet Union and abroad to work out a common approach in regard to methods which would enable the results obtained by different investigators to be examined and generalized. Remezov' paper submitted at the Seventh International Congress of Soil Scientists in 1960 was devoted to these questions of program and methods.

Remezov's considerable scientific achievements are largely the product of a happy combination of qualities, for he is both a naturalist who loves and understands nature and an empirical scientist with a mastery of the methods of precise research.

No account of Remezov's scientific career would be complete without a mention of the great work he has done in popularizing soil science, in investigating its history, and in familiarizing our scientific community with the original works of foreign investigators (he has edited translations of monographs by Mattso and Russell, edited the works of K. K. Gedroyts, and produced essays on the scientific work of Gedroyts, D. N. Pryanisnikov, K. D. Glinka, V. V. Gemmerling, A. F. Tyulin, and others.

Remezov has taught a great many scientists, including 26 candidates in science and 3 doctors of science. His teaching work is an inseparable part of his creative life. His lectures attract not only under-graduates and research students but also members of the scientific staff. He is the author of a textbook on the properties and distribution of soil. This textbook was supplemented by an edition in the Ukrainian language and won the author of the Vil'yams prize offered by the Timiryazev Academy of Agriculture in 1957.

Remezov has published more than 100 scientific works, including several widely known monographs.

He has reached his fortieth jubilee of scientific activity full of vigor and is still doing creative work. In 1959 he was elected as Director of the Soil Science faculty and appointed Director of the Soil Department of the Biology and Soil Faculty at the University of Moscow.

We wish him good health, a long life and further success.

REVIEWS

CHANGEABLE ADSORPTION IN THE SOIL AND HE AVAILABILITY OF NUTRIENTS BY PLANTS

V. PETERBURGSKIY, "Vysshaya shkola," 1959, pp. 251.

Peterburgskiy's book on the important theo- ical and practical problem of adsorption by ls and the availability of nutrients has now en published. In its more detailed form this rk was awarded the Pryanishnikov prize for 55.

Soil scientists and agricultural chemists are, course, greatly interested in this problem. iet scholars have contributed much to its dy. The classical works of Gedroyts and yanishnikov and the studies of their pupils successors are well known as authoritative tributions. The author of this review is one Pryanishnikov's pupils.

Peterburgskiy's long years of original work e fitted him for the task of presenting in a dable form the latest data on adsorption and availability of nutrients from the exchange- e complex of the soil and from solutions. The hor has broken down this general task into umber of partial aspects. He has made a nstaking study of the literature, systematized own experimental data and those of others, presented his main conclusions in a highly entific manner.

There is an intimate connection between the blem of the adsorption and availability of nutrients to plants and the theory of the ucture of the soil's solid phase, the interac- between soil and solution and the relation- p of the soil as a medium with plants. All se different aspects of the problem are dealt h in the book. The importance of the subjects lt with can be seen from an incomplete list of chapters: Plant and soil and their relation- ps in the process of root nutrition, the effect he reaction (pH) of the medium on the entry nutrients into the plant, plant metabolism crop growth, the modern concept of the ry of nutrients into plants via the root system, sible utilization of nutrients from dry soil the plant, features of cation exchange in y minerals, availability of adsorbed cations, ion exchange between roots and soil colloids, orption of anions by the soil and their avail- lity to plants, importance of the vital activity he microorganisms of the rhizosphere to the ake of ions from adsorbents by plants.

The author bases himself on the contemporary logical view of the intimate connection be- en the internal and external conditions of life of the plant. He relates the intake of nutrients into roots from the soil with oxidation processes, and especially with the respiration of the root system. Adsorption of ions from the external solution by root hairs is treated as an exchange process. The adsorbing surface of the root gives up ions that arise in the electrolytic dissociation of carbonic acid (from the carbon dioxide exhaled by the roots) in exchange for the adsorbed ions. Great importance is attached to the organic acids discharged by the roots. Since respiration reflects the progress of metabolism in the organism, the entry of ions from outside is thereby connected with other physiological processes occuring within the plant. The intensity of these processes governs both the total extent of ion uptake through the roots and the ratio between the adsorbed cations and anions.

These root secretions are an important factor in the plant's influence on the soil. The author gives some brilliant experiments to demonstrate the role of close contact between the soil and the assimilating surface of the root system in nutrition by the ions adsorbed by soil colloids.

It follows from these experiments that the assimilation of nutrient ions from an adsorbed state by plants cannot be explained by the hydrolysis of the adsorbents, independent of the vital activity of the root system, or solely by participation of the microorganisms in the rhizosphere in the displacement of adsorbed ions in solution. The major role belongs to the plant itself and its root secretions. This is established from crops of different biological features both for separate cations (potassium and others), and for the total nutrition of plants with all the ions essential to normal crop growth (macro-and microelements) by adsorbed ions. Optimum conditions for plant nutrition are created when both adsorption-bonded ions and soluble salts are present in the medium surrounding the roots, as in the natural growth of field crops.

The appearance of Peterburgskiy's useful book should be welcomed, since no one else has as yet published a work covering all the questions enumerated. It should also be added that the book is well written. Since each chapter concludes with a short summary and many sections are illustrated by experimental data and photographs, the conclusions are convincing and more intelligible to the reader.

It is a pity that the edition is as small as 3500 copies.

Although we have a high general opinion of the book, a few critical remarks should be made.

Although the author's great attention to the soil as a polydispersed and polymineral system is extremely valuable, he is, in my opinion, guilty of certain inaccuracies and, at times, of unclear expression. On page 12 he writes: "The most important clay minerals present in the soil in a colloidal state are kaolinite and montmorillonite, that are the most widespread representatives of the two large mineral groups." There are two inaccuracies in this quotation. Firstly, kaolinite is encountered comparatively rarely and only predominates in soils developed on the eluvium of primitive rocks (in red earths, lateritic soils and other soils on the eluvium of granites and andesite-basalts). Secondly, kaolinite is usually found in a less dispersed state than colloidal. Kaolinite normally has large crystals distinguishable under a simple microscope. A little further on (p. 16) the author points to the presence of a hydromicaceous group of minerals in the soil. This group should occupy first place both for distribution and for agricultural chemical significance, since it is often a source of available potassium. Montmorillonite is clearly found in a blend or in a complex structural relationship with hydromicas and is rarely encountered in pure form. Some authors consider that the beidellite encountered in the soil is a complex combination of montmorillonite and hydromicas.

Our data do not support the opinion of soil scientists that kaolinite predominates in podzolic soils (p. 12). There is no need to examine this question in detail here, but it should be emphasized that if kaolinite predominated podzolic soils would not contain potassium in the clay fraction. In fact this fraction contains more than 2% of potassium, its adsorption capacity reaches 50 meq per 100 g, the $SiO_2:R_2O_3$ ratio in it is normally 2.5 to 3.

It is unfortunate that the book makes no mention of such non-clay minerals as goethite, hydrargillite and calcite, which are of great importance for the properties of soils and, in particular for P_2O_5 adsorption.

The author pays a great deal of attention to the isomorphic substitution of ions in the crystal lattice. This important mineralogical question is scarcely of great importance in agricultural chemistry. Isomorphic substitutions are possible in hydrothermal processes, i. e., at high temperatures. Under normal soil conditions such substitutions are highly unlikely. Even if they did occur, intracrystalline exchange would predominate over surface exchange, of which there is none. If all the cations of the crystal lattice were replaced in montmorillonite, its adsorption capacity would be 400-500 meq/100 g, but it is in fact 4-5 times less.

The adsorption of phosphate ions by their exchange for ions within the crystal lattice is highly improbable.

Increase in the dispersion of clay and non-clay (including primary) minerals leads to an increase in the adsorption capacity of cations and phosphates. It is highly probable that phosphate ions are adsorbed by aluminum and iron, which are found, on dispersion, on the outer surface of the colloids.

Both the title of the book and its content direct the reader to the main importance of exchange reactions. This point of view is indisputable, but it should be stressed that exchange reactions are always accompanied by other intimately associated reactions, which can sometimes not be separated. It is known, for example, that soil colloids containing aluminium on the surface adsorb more phosphorus than sodium saturated colloids. One should admit that part of the phosphorous is adsorbed after the aluminium has passed into solutio and that part is bonded by the free valencies of the aluminium without passing into solutions. Further, diffusion of salts into the tissues of the root is clearly possible at the same time as the exchange adsorption of ions by the root surface. In view of this it seems to me that the laws of biology and of physical chemistry should not be so sharply contrasted. In advancing data on the high rate of uptake of ions in the plants and the higher concentrations of salts in the plants than in the solution, the author considers that the laws of osmotic pressure and diffusion lose their force when applied to living organisms. In fact these laws are included in the biological law and are made more complicated and masked by the features of the organisms. When examining the rate of ion uptake by plants one should stress the quantitative aspect of the phenomenon. It has been shown by using isotopes that the rate is very high, but that the bulk of the nutrients enters slowly.

The author's view on the adsorption of anions especially monovalent NO_3, NO_2 and Cl is not quite clear. Many experiments show that these anions are not adsorbed according to the laws of exchange adsorption. They do not give rise to insoluble compounds and have the same charge as colloids. Consequently, they can only be adsorbed as a result of diffusion or by the positively charged particles of colloids, of which there are clearly few, while adsorption by the displacement of ions from the lattice is improbable.

The importance of minerals in the adsorption of cations and anions is often examined in the literature without taking the dispersion of the minerals into consideration. The author of this book, who quotes the data of various authors, also fails to pay attention to dispersion, and thus ascribes self-sufficing importance to mineralogical composition. It is indicated on p. 17 that more phosphate ions are adsorbed by kaolinite than by montmorillonite. This is explained by the exchange of the hydroxyl ions of the crystal lattice for phosphate ions. Kaolinite usually adsorbs less phosphate ions than montmorillonite, but if kaolinite is dispersed to the particle dimensions of montmorillonite it is a considerably better absorbent than montmorillonite owing to its relatively higher content of aluminium. Consequently, the explanation we have given concerning the surface nature of adsorption is more correct. We do not therefore share the opinion o Peterburgskiy, who indicates (p. 66) that these latter facts deny the possibility of absorption of this kind. We are not convinced by Peterburgski references to the works of a number of authors.

These comments do not alter our opinion that Peterburgskiy's book is useful and necessary.

Reviewed by N. I. Gorbunov

TEXTBOOK ON AGRICULTURAL CHEMISTRY AND SOIL SCIENCE

F. SCHEFFER and B. ULRICH, Part III, Humus and Humus Fertilizers, Vol. 1. Morphology, Biology, Chemistry, and the Dynamics of Humus, 266 pp., Stuttgart, 1960.

This monograph is one of a series of textbooks on different branches of agricultural and soil science published by Scheffer in collaboration with other scholars in the past few years. It is the second revised edition of a book of the same name issued by Scheffer in 1941.

The book consists of six chapters occupying 238 pages and a bibliography, devoted primarily to new literature, containing approximately 1300 entries.

Chapter I defines the forms of humus[1] (determined by differing morphological state), the composition of humus, including organic matter of plant and animal origin (Nichthuminstoffe), and humic matter proper (Huminstoffe), as well as of the varieties (Art) of humus classified by functional criteria (e. g., organic matter forming complex compounds and chelates; compounds containing P, N and other elements).

Chapter 2 is devoted to humus morphology: it describes the main subaqueous forms of humus (sapropels and others), semi-above ground (transitional peat bogs, surface peats, etc.), and various forms of soil humus (raw humus, mor, mull) with more detailed sub-divisions. Kubiena's key for the determination of humus forms is given at the end of the chapter.

Chapter 3 examines questions relating to humus biology. The complexity of the soil fauna is noted and the authors indicate that the most important factors determining its composition are: porosity of the soil (that provides living space for the organisms), the amount and nature of litter fall (that provides food and a source of energy for the organisms), microclimatic factors (temperature and moisture), the composition of the atmosphere (content of oxygen and carbon dioxide), light (total energy and the ultraviolet part of the spectrum) and, finally, the chemical nature of the medium (reaction, salt content, presence of nutrient and biotic substances).

After dealing briefly with the composition and numbers of the main groups of microorganisms and of the micro- and macro-fauna, the authors conclude the chapter by examining the main functions of the soil microflora and fauna in the conversions and transportation of matter in the creation of soil structure, in the interrelations of the various groups in the biocoensis, and in plant nutrition. The main views are developed in the later chapters of the book.

The fourth chapter, humus chemistry, is one of the main chapters. It also includes materials on the chemistry of plant substances, the biochemistry of their conversions in humification, and in the biochemical and chemical synthesis of humic matter.

In classifying humic matter[2] as stable forms of organic material, the authors note that since Ahard and Sprengl, and down to the present, the most widely accepted approach for separating the substances from the soil has been the use of alkaline extracts (such as NaOH). The humic matter is divided into humic acids that are precipitated by acid, and fulvic acids that are not precipitated.

The authors use the latest research in their exposition of the basic principals of the structure of humic matter (the nature of the nucleus, the main groups, the disposition of the structural elements in the particles — molecules, their weight, etc.). The sections of this chapter containing materials that various authors have obtained by the use of new methods (electrophoresis, ultracentrifugation, cromatography, etc.) are extremely interesting. These methods have demonstrated the heterogeneity of the humic, fluvo-and hymatomelanic acids, and the possibility of separating a number of fractions by their compositions.

The latest research (especially with infrared spectroscopy) has revealed the absence of any basic differences in the structure of the separate humic groups. The only main difference between hymatomelanic acids, grey and brown humic acids, and fulvic acids, is in the level of polymerization of the particles (the authors point out that polymerization should be understood as an increase in the dimension of the particles by the addition of a new nucleus, and as increased condensation of the nucleus when the weight of the particles is the same). This latter factor explains how one group of humic matter may be changed into another (fulvo-and hymatomelanic acids, for example, into humic acids).

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[1] Treating soil humus as a dynamic system, the authors include dead organic matter and actual humus substances in the concept "humus."

[2] We are using the terminology of the authors. In Soviet literature the term "humus substances," that includes the humic and fulvic acid groups, and others, is more generally used.

The second half of the fourth chapter is devoted to questions connected with the formation of humus. There is a brief description of the main groups of plant substances (hydrocarbons, lignins, and nitrogen — containing organic compounds) and their conversion in humification. There is also an examination of possible pathways for the synthesis of humic matter from phenols and quinones by self-oxidation in an alkaline medium and by enzymatic oxidation.

The authors show from new experimental materials on the polymerization of hydroquinones in the presence of cations that easily change their valency (e. g. Fe^{+++} and also in heterogeneous catalysis with quartz and silicic acid of ferric oxide and hydroxide), that these pathways are also possible in the formation of humic substances. However, although the importance of enzymatic catalysis in this process had been established by the beginning of the century by Trusov, clarification of the role of inorganic catalysis in the formation of the humic substances of the soil requires further research.

The fifth chapter contains materials on the composition of the different forms of humus in soils. These forms can be quantitatively determined in the following ways:

1. Determination of the principal plant substances (such as, for example hemicellulose, celluloses, and lignin) by plant analysis or by group humus analysis.

2. Separation of humic from non-humic matter by treatment with acetylbromide.

3. Extraction of humic substances from the soil by dilute alkaline solutions or by certain other solvents, followed by fractionation.

The authors note, however, that these methods only give an approximate idea of the nature of humus. The chapter contains data for various soils to show the ratio of non-humified and humified forms in their humus, the content of total nitrogen and its forms as a percentage, the relative content of humic and fulvic acids, and certain other indices. It is also indicated that there has recently been a revival of interest in study of the groups of non-humic matter, especially the carbohydrates and organic acids and nitrogen-and phosphorus-containing components. Improved methods for the quantitative determination of these substances have undoubtedly assisted their study.

The next section of the chapter deals with the nature of the humus and organo-mineral soil complexes and their role in the preservation of proteins, in the aggregation of the soil, in the formation of the soil profile, and in other respects.

The sixth and final chapter is entitled "Humus Dynamics." The authors list the possible sources from which organic material can enter the soil (plant residues in the form of roots and litterfall, organic fertilizers, plant root secretions, and the plasma and metabolic products of microorganisms), and give values for the quantities that enter. Materials on the role of microorganisms in the formation and decomposition of humic substances are an important section of the chapter. The first process (the formation of humic substances) can follow various paths:

1. Formation within the cells of certain organisms; 2. Conversion of pigments of a quinoid nature into humic substances when microbial plasma undergoes autolysis; 3. Oxidation of the aromatic compounds of the substrate by the ectoenzymes of living microorganisms; 4. The formation of humic substances from the autolysis products of microbes. Many studies show that all these humic substances are very similar in nature to soil substances.

The decomposition of humic substances by microorganisms is no less important. References in the literature show that various microorganisms make little use of the substances as a source of nitrogen and in particular of oxygen. However, the addition of easily available organic compounds (glucose and protein) to humic substances accelerates their decomposition.

A considerable part of this chapter is devoted to an examination of the many-sided participation of humus in soil genetic processes. The treatment of the processes of gley formation, podzol formation and loess formation from the point of view of the formation of different forms of organo-mineral compounds is of great interest.

Using the latest data on the nature and properties of organic substances the authors examine their importance in the water and thermal properties of the soil, and its gaseous regime. Considerable attention is paid to the physiological functions of humus which contains different biotic substances (auxins, antibiotics, stimulaters of the biochemical and physiological processes of plants) in the section of the role of humus in plant nutrition. The varied products of the decay and exchange of substances in plants, and in the soil microflora and fauna, and the decay products of the complex molecules of the humic substances are dealt with in this section.

In concluding the brief review of this book, we should like to note the following:

There has recently been considerable interest in the study of soil humus (especially since the Second World War), resulting in a vast flood of literature that has been systematically published in many countries. New techniques and research methods have enabled us to reveal important aspects of the nature and structure of humic substances, the mechanism of their formation, and their participation in soil processes.

From this point of view, this monograph which summarizes both the recent literature and research on soil humus at the Institute of Agricultural Chemistry and Soil Science in Goettingen University (of which the director is Professor Scheffer), can be of use to research workers dealing with this problem.

Reviewed by N. M. Kononova

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